A CAHNERS PUBLICATION

SEPTEMBER 20,1974

Tony 1

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Quad linear contest winners show high creativity

A hardware approach to using a microprocessor

Intelligent instruments boast high IQ's

NEW

PANDUIT® Pneumatic Cable Tie Installation Tool

- Lightweight, easy operation – reduces fatigue
- Versatile – one tool installs 36 cable tie sizes
- Fast – high-volume production

Introducing the ultimate in pneumatic, hand-operated cable tie installation tools. The new PANDUIT® PPTS air tool was designed for high-volume production requirements with operators' comfort in mind.

Minimum operator fatigue. New lightweight tool requires minimal force. Comfortable for continuous high-volume use. No training required.

Most versatile. One tool installs all miniature, intermediate and standard cross-section PAN-TY® and STA-STRAP® cable ties, clamps, marker ties and push mount ties – 36 different sizes, bundles to 4" diameter.

Fast, uniform tensioning, cut-off. Tool uses standard 70 to 80 psi air to automatically tighten cable ties to pre-set tension and cut flush. No sharp edges. No metal barbs. No twisting.

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Circle No. 1

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Ask for descriptive bulletin and demonstration.

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SEPTEMBER 20, 1974
VOLUME 19, NUMBER 18

EDN

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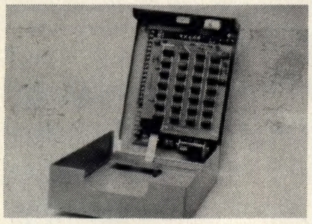
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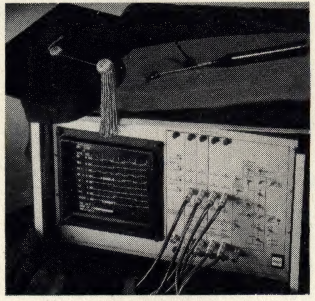
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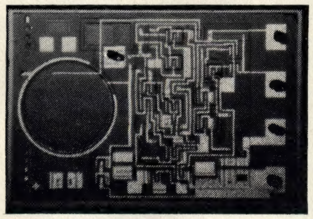
Optical IC's . . . . pg. 86

COVER

Intelligent instruments truly reflect the system approach to electronic design in concert with today's latest technology: LSI. So dedicated, they become more adaptive by using ROM's or μP's, all aiming to minimize the judgment and error of human participation. This is well emphasized in the articles starting on pgs. 28 and 40. Our cover photo, supplied by the E-H Research Laboratory, shows a "degreed" example of an intelligent instrument.

DESIGN NEWS

Fifty years of technological improvement – in one step 20
One small microprocessor chip equals one giant step for industrial camera systems . . . Here's your chance to learn how to write for publication . . . TIPI computerizes Air Force tactical operations . . . Spectrophotometer-computer system is valuable food-research tool.

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Here's a down-to-earth approach for letting the microprocessor itself teach you what it's all about.

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BPA ABP

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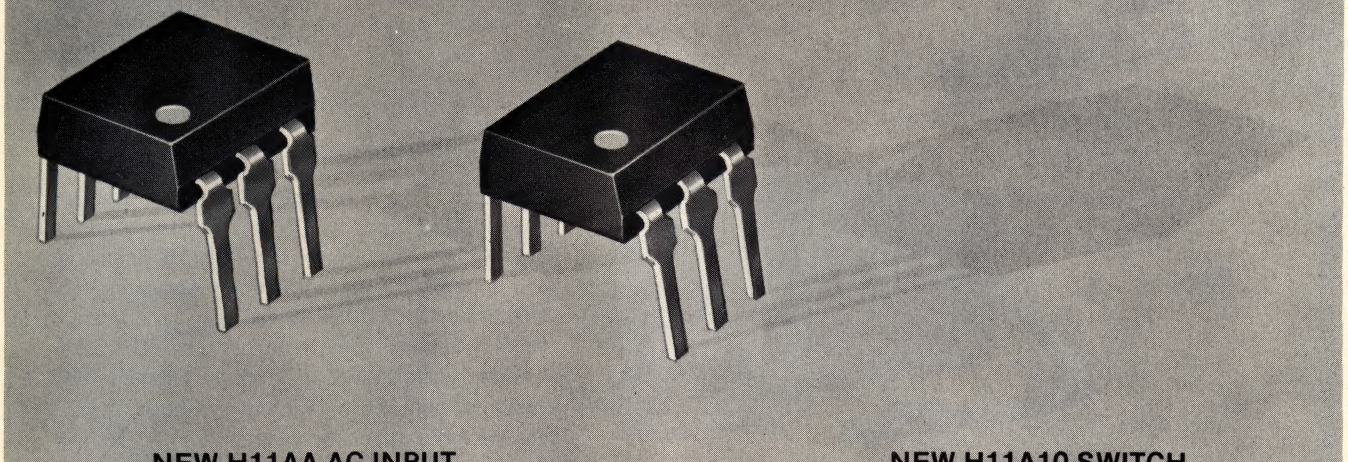

NEW H11AA AC INPUT

- 2 LEDs reverse connected for bidirectional inputs
- 1500 V isolation, 20% min current transfer ratio
- 10% symmetry
- $1.65 each, 1000 lot quantities

NEW H11A10 SWITCH

- Programmable threshold detection triggerable by 2:1 change in I_{IN}
- 1500 V isolation, 10% min current transfer ratio "on" state
- Covered under "UL" file E51868
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Semiconductor Products Department, Syracuse, N.Y.

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engineering and

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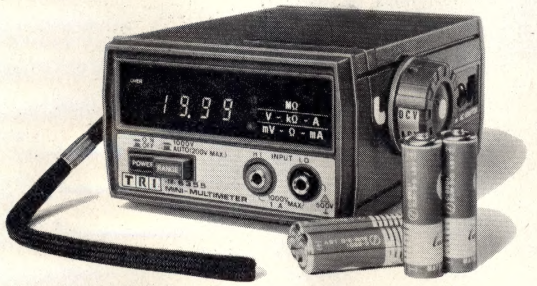
Price **$279.00**



Model: 6355
Mini-multimeter

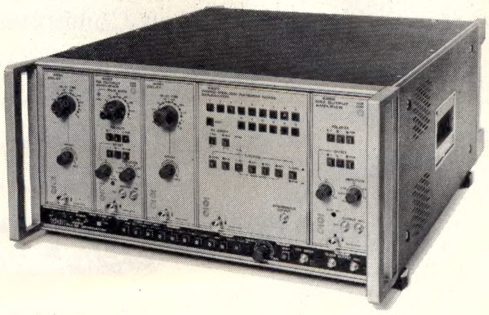
- Five functions. Automatic range selection.
- Drop-proof, portable (4-3/8W, 2-7/8H, 6D in.), Lightweight (1.8 lb)
- High performance—DCV measurements at 10 μV resolution. ACV measurements up to 1000 Vrms.
- Operates on DC battery and AC power supply.

10 μV, Fully automatic DMM. $279

Announcing the fully automatic, 10 μV resolution Model 6355 portable DMM standard. And at only $279. Not only that, but also 5 functions and automatic range selection. Measures AC voltages up to 1000 Vrms, can even be operated from a battery. The same performance as a laboratory use DMM. Can be easily hand carried. Weights only 1.8 lb. Moreover, shock resistant design protects it even if it is accidently dropped. Five auto functions range switching, units display, polarity, overrange indication, and overload protection.

Display: 1999 **DC Voltage:** 20 mV – 1000 V (resolution 10 μV) **AC Voltage:** 200 mVrms – 1000 Vrms (resolution 100 μV) **Resistance:** 200 Ω ~ 20 M Ω (resolution 100 m Ω) **DC Current:** 20 mA ~ 1 A (resolution 10 μA) **AC Current:** 200 mA ~ 1 A (resolution 100 μA) **Size:** Approx 4-3/8 (W) × 2-7/8 (H) × 6 (D) in. **Weight:** Approx 1.8 lb **Price:** $279

Repetition rate **500 MHz**



Model: 4220
Pulse Generator

Maximum repetition rate up to 1000 MHz make it ideal for PCM communication.

Model 4220 is a high-performance pulse generator with a repetition rate of 500 MHz. It can also generate word patterns. Among the main features of this high performance instrument is generation of a multitude of waveforms through combinations of different modules. Eight modules enable pulse generator tailoring to a specific requirement. Each unit also has a remote control function and such complementing features as delay of 1 or more periods, 50Ω output impedance which enables generation of highly accurate pulses, variable rise and fall time, and two outputs.

Repetition Frequency: 100 kHz – 500 MHz **Modules:** Delay, double pulse gate, word generator, word/pseudo random noise generator, NRZ output amp, RZ output amp, RZ output amp (rise time/fall time variable), bipolar output amp.

Product Line to Innovate production ideas.

TRI

T.R.I. CORPORATION
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(408) 733-9080

Programmable

Model: 6141
Programmable DC V/I Generator

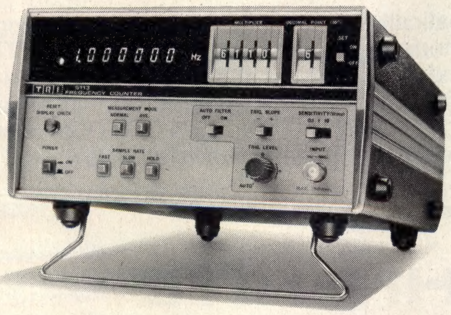
- Economy plus programmbale functions suitable for a host of OEM applications.
- Easy flip-switch operation.
- Extremely stable. Also has pulse-width modulation system.
- Variable in 1μV steps. All-range continuous-function performance.

Suitable for OEM and production line use.

Model 6141 features a remote control function for OEM use and wide usage on production lines. These unique features have been made possible through the adoption of a new pulse-width generator system. Easy usage has been realized through the adoption of a flip switch to automatically set the output level with one touch instead of the conventional rotary switch. Since automatic carry is performed when this switch is depressed, automatic sweep is also possible.

DC Voltage: 0～±11.999V (1μV steps) **Stability:** ±0.015% of setting ±3μV (10 mV range) **DC Current:** 0～±119.99 mA (0.1μA steps) **Stability:** ±0.02% of setting ±0.2μA (1μA range) **Dimensions:** Approx 11-3/4 (W) × 3-5/16 (H) × 10 (D) in. **Weight:** Approx 11.023 lb **Price:** $890

Resolution **0.00001Hz**



Model: 5112/13
Milli-Hertz Counter

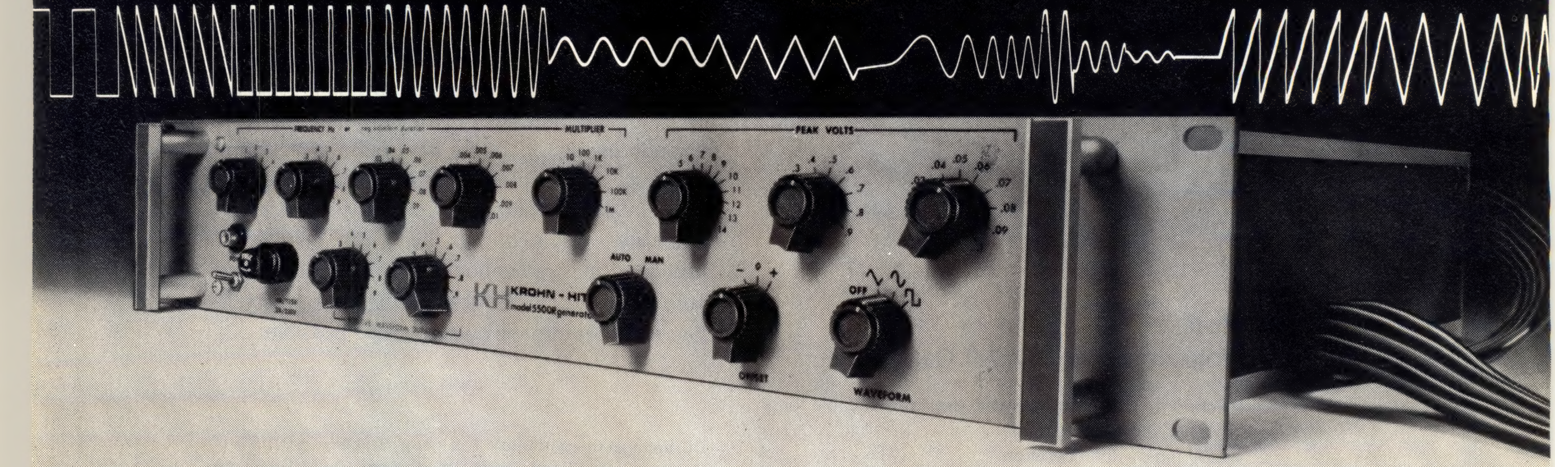
High resolution counter which permits direct reading of rotational speed and flow rate.

Model 5112 and 5113 are revolutionary products which permit direct-reading measurement of rotational speed, flow rate, and other comparatively low frequencies (1 Hz～1 MHz) at high accuracy in these respective units. Moreover, measurement accuracy has been increased through the averaging function. The measured result can be directly displayed and a multiplier function is employed to directly read physical quantity.

Frequency Range: 1 Hz～1 MHz **Resolution:** 0.1 mHz (Model 5112), 0.01 mHz (Model 5113) **Display:** 199999 (5112), 1999999 (5113) **Size:** 8-7/16 (W) × 4-2/4 (H) × 12-15/16 (D) in. **Weight:** Approx 11.02 lb **Price:** $1300 (5112), $1400 (5113)

Circle No. 15

New
function generator
programs faster–
functions better,
longer.



The 5500R Programmable Function Generator utilizes high-speed FET switches for greater reliability and generates functions automatically in less than 100µ sec.

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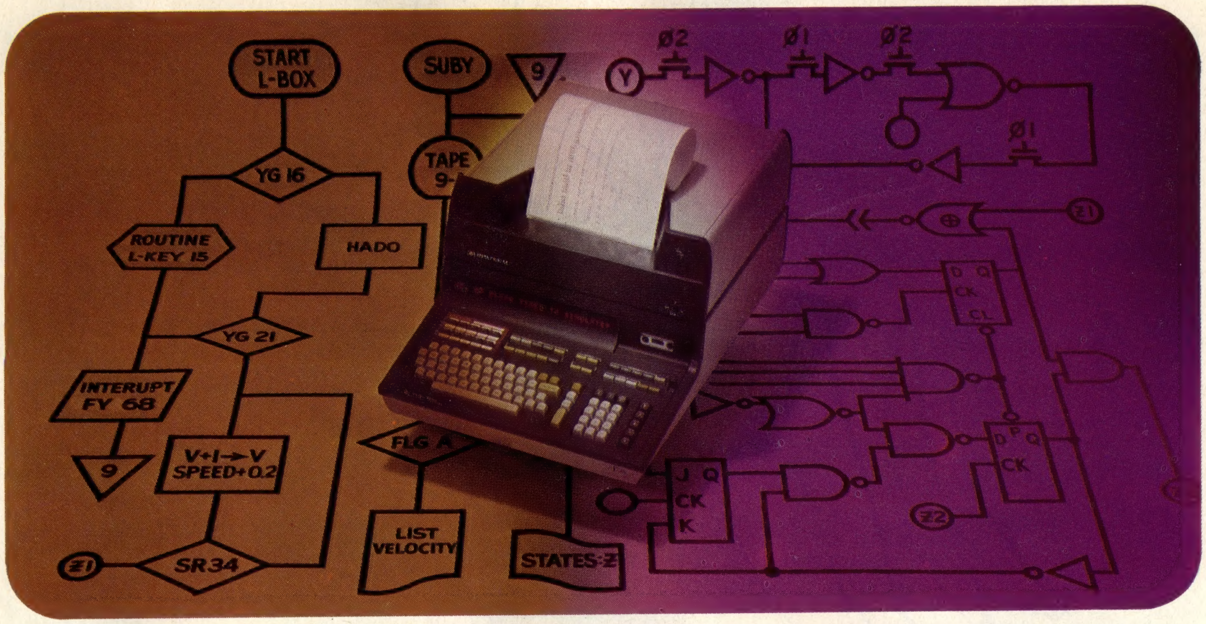

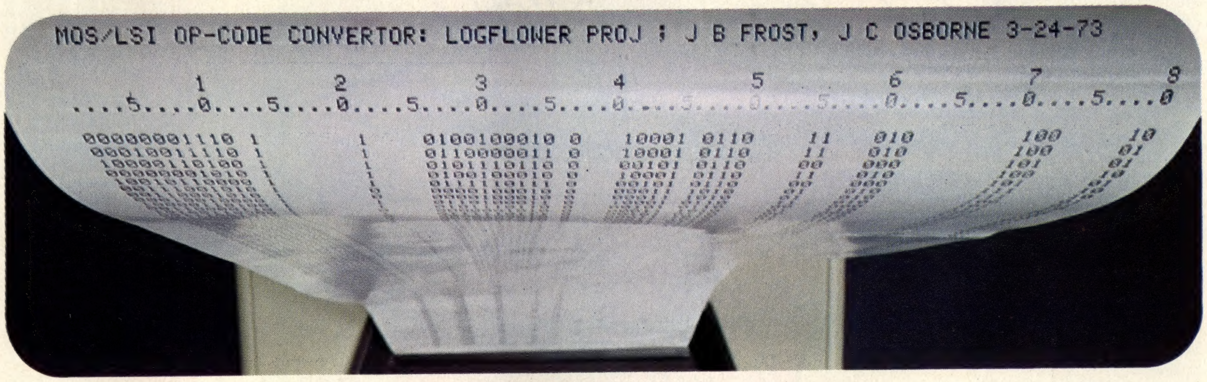

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MOS/LSI OP-CODE CONVERTOR: LOGFLOWER PROJ ; J B FROST, J C OSBORNE 3-24-73
         1         2         3         4         5         6         7         8
....5....0....5....0....5....0....5....0....5....0....5....0....5....0....5....0
 00000001110 1          1     0100100010 0    10001 0110     11    010        100     10
 000100111110 1         1     0110000011 0    10001 0110     11    010        100     01
 10000110100 1          1     0101110110 0    00101 0110     00    000        101     01
 00000001010 1          1     0100100010 0    10001 0110     11    010        100     10
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Circle No. 18

On designing to impress

I recently received the following comment from a reader. He was disappointed in our Creative Design Contest winner, the Kerber Klock (EDN July 20, 1974, pg. 44). He said, "All digital design is basically 'cookbook' and 'plug-in formulas.' Sophomore students at MIT's digital lab do more impressive projects." Think about that philosophy for a moment! Perhaps you will find such ideas bother you as much as they do me.

Criticism of our selection isn't upsetting. That's often a matter of opinion and I accept it. However the philosophy of designing to be impressive rather than practical and useful is fraught with danger for any company who seeks to turn a profit on its new products. I'm sure you've seen as many "impressive" designs as I have that were dismal failures. Unless they serve a useful purpose and are *marketable*, the design is an exercise in futility and a waste of money.

What's wrong with cookbook designs and plug-in formulas? Isn't that the lifeblood of our industry—standard products in high-volume production? How many products today are "impressive" state-of-the-art designs? Not many! The truly successful ones use proven off-the-shelf-parts in a unique but essentially cookbook fashion. They are impressive not necessarily from a complicated viewpoint but for their utility and often simplicity. A good designer will try to make his design as simple and cost effective as possible, since that's where the profit dollars are. Take the pocket calculator as an example.

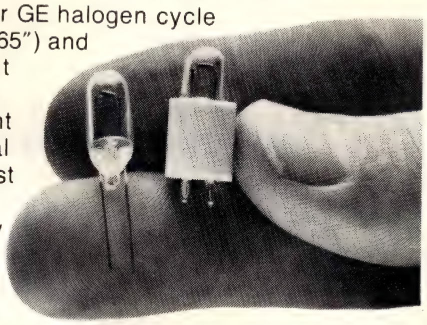
More times than not it's much more difficult to design a product using standard "cookbook" parts, keeping parts count down, than it is to design a sexy, complicated one. Those engineers who "design for utility" vs. "designing to impress" are the ones who will make it—especially in these days when so many companies are feeling the economic squeeze.

Roy W. Forsberg

Editor

New and improved General Electric lamps provide for increased design flexibility.

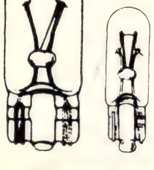
Two new sub-miniature halogen cycle lamps ideal for miniaturization.



These new T-2, 6.3V, 2.1 amps, 75 hour GE halogen cycle lamps are the smallest of their type (.265") and set industry standards for size and light output (16-20 candlepower). They are perfect for miniaturization of equipment such as reflectors, housings and optical systems. They also save on overall cost of equipment and are less than half the cost of the #1973 quartz lamp they replace.

Two terminal configurations are available. #3026 (20 candlepower) has wire terminals. #3027 (16 candlepower) has a new two pin, ceramic base that plugs in to make installation and removal a snap. Samples of the #3027 lamp are available in limited quantities now; production quantities will be available in the first quarter of 1975. These lamps have an iodine additive that creates a regenerative cycle that practically eliminates normal bulb blackening. They will produce approximately 95% light output at 75% of rated life.

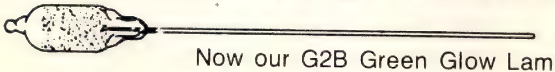
An expanded line of Wedge Base Lamps for simple, low-cost circuitry.



Now you can have greater design freedom than ever before with wedge base lamps. GE now offers six large lamps in its line of T-1¾ (.230" max.) all-glass, sub-miniature wedge base lamps. In addition to our three 14V lamps (#37, #73 and #74), we now also offer two 6.3V lamps (#84 and #86) and a 28V lamp (#85).

These lamps are ideal for applications where space is at a premium. Their wedge-based construction allows you to design for low-cost sockets and virtually ends corrosion problems because they won't freeze in the sockets. And the filament, which is always positioned in the same relation to the base, offers more uniform brightness.

Green Glow Lamp has been improved over previous lamp.



Actual Size

Now our G2B Green Glow Lamp, the only domestic green lamp on the market today, gives a more uniform, purer green light than our previous model. It's bright enough for your circuit component applications. With appropriate current limiting resistors, it can be used for 120/240 volt green indicator service. Or used together with our high-brightness C2A red/orange/yellow glow lamps to emphasize multiple functions with color.

All GE glow lamps give the benefits of small size, rugged construction and low cost — 12¢ each for the G2B, 4.4¢ each for the C2A in 100,000 quantities.

Send today for newest literature.

For the most up-to-date technical information on any or all of these lamps, write: General Electric, Miniature Lamp Products Department, #0749-K, Nela Park, Cleveland, Ohio 44112.

GENERAL ELECTRIC

Circle No. 19

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Boston, MA 02116

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These new Unitrode 300V power darlingtons

perform like this

I_C A	V_{CEO}† V	h_{FE}	$V_{CE\,(sat)}$ V	Type No.	Package (Modified)	Polarity
2	300	1000 @ $I_c = 1A$	1.5* @ 2A	U2T103	TO-33	NPN
2	300	1000 @ $I_c = 1A$	1.5* @ 2A	U2T203	TO-66	NPN
5	300	1000 @ $I_c = 3A$	1.5* @ 5A	U2T303	TO-3	NPN

†V_{CEO} measured at 10 mA *Forced gain = 100

and...

Like all Unitrode Power Darlingtons these new 300-volt units exhibit the lowest saturation voltages available.

Like all Unitrode Power Darlingtons their short turn-on and turn-off times mean unusually high efficiency in fast-switching applications.

Like all Unitrode Power Darlingtons they give you greater savings in design and assembly time and lower component cost than is possible with discrete components.

Like all Unitrode Power Darlingtons they are planar for the highest reliability and stability.

Unitrode's full line of Power Darlingtons includes PNP and NPN transistors and a wide choice of characteristics in single and dual, mixed or matched, units.

Send for complete details on the entire line of Unitrode Darlingtons. For faster action, call Peter Jenner at (617) 926-0404. Describe your application on your company letterhead and we'll send a suitable sample.

Circle No. 20

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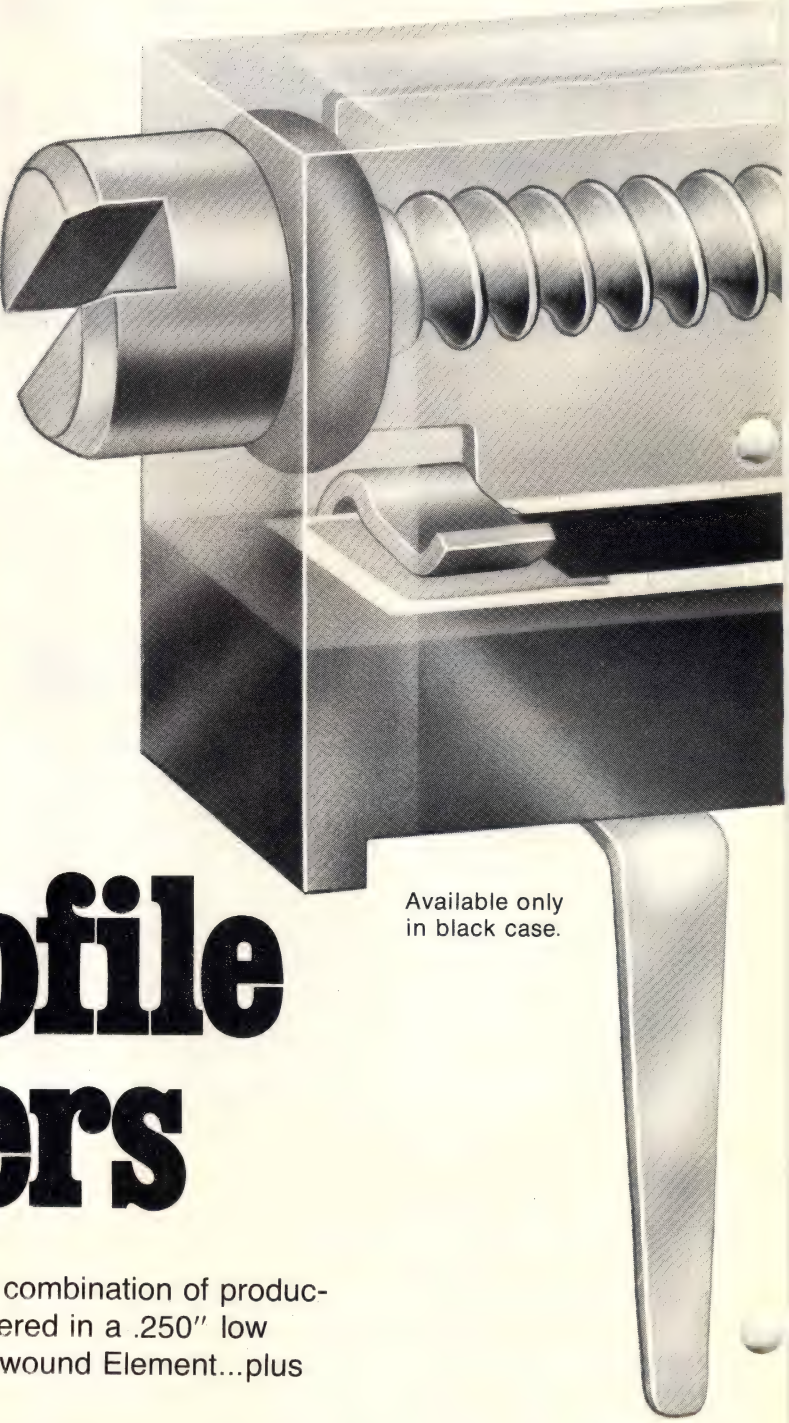

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Dale's new 700 Series gives you the best combination of production and performance advantages ever offered in a .250″ low profile package. Choice of Cermet or Wirewound Element...plus good delivery and low price.

Better Adjustability: Cermet models provide output resistance of ±0.10% and output voltage ratio of ±0.05%.

Higher Power: All models offer 1 watt power dissipation at 70°C.

Low T.C.: 100 PPM for all cermet models, 50 PPM for wirewound.

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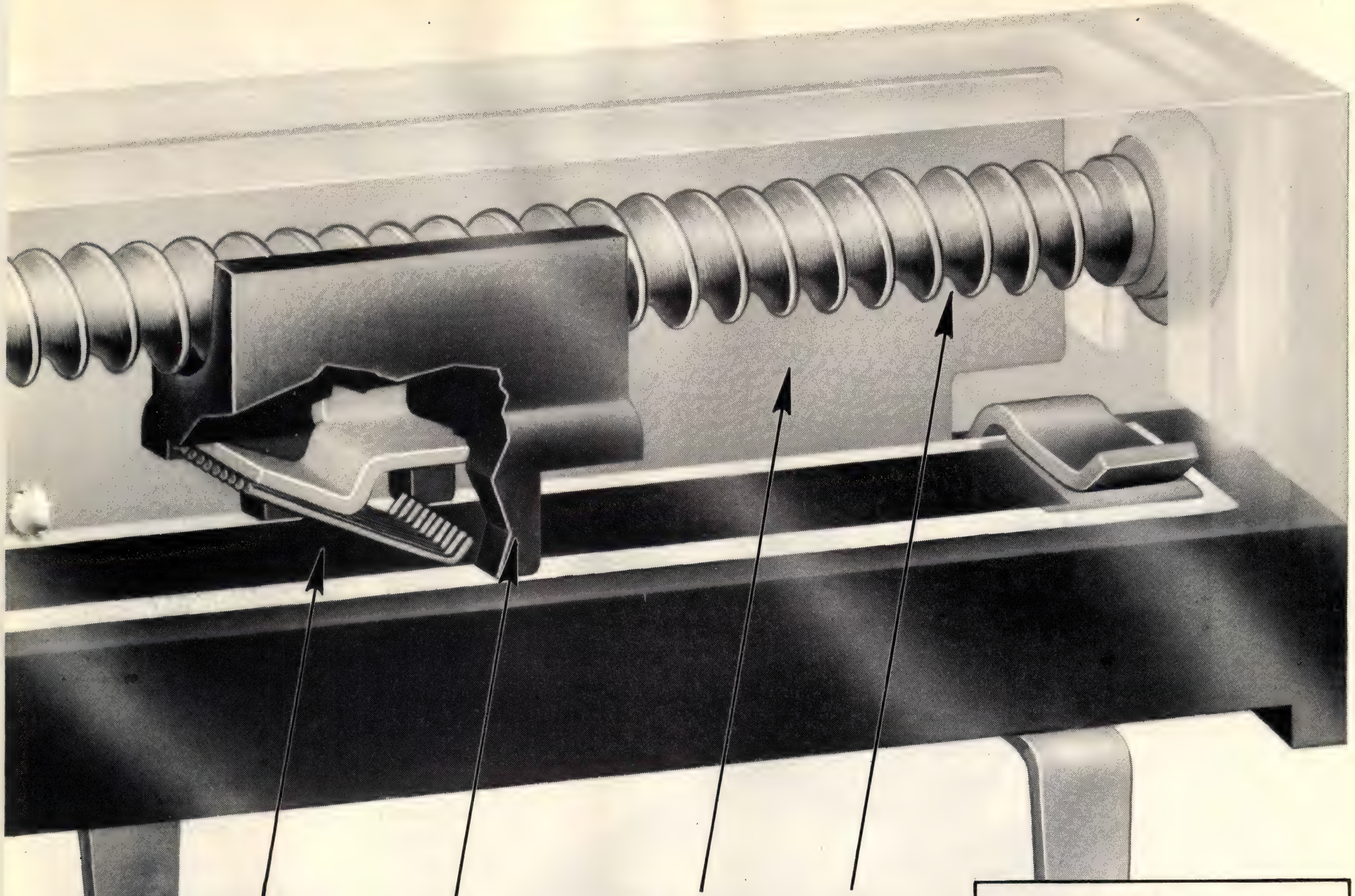

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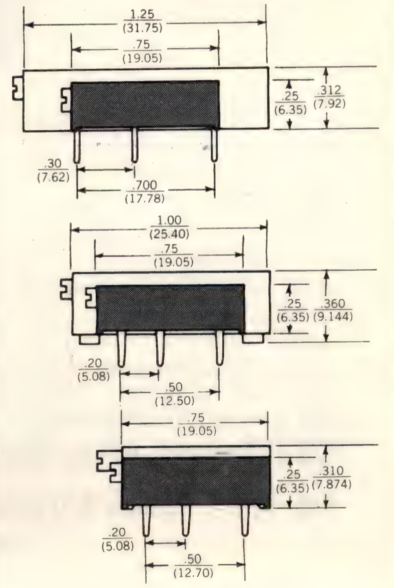
All Metal Screw. 25-turn adjustment. One-piece clutch prevents overtravel damage.

Improved Package Density 3 standard pin spacings allow fast interchange with many larger models.



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Circle No. 21

"When engineers saw they didn't have any knobs, they were scared they'd lose control, but now they're in love with the thing."

Slightly over a year ago, American Microsystems, Inc. ordered their first Fairchild Sentry 600.

Today, nine Sentry 600's are on line at AMI. Number ten is on its way. Each system was carefully evaluated by AMI. And then the next ordered. The result? AMI is now the largest purchaser of Fairchild's Sentry 600. It's a happy association.

So happy, indeed, that when AMI offered to brief our people on their side of the story, we asked if we could publish some of their comments. They're reproduced here.

The validity of their comments? Each uses Sentry 600, relies on Sentry 600, and has one or more Sentry 600 systems in their department: Ed Carcher, Manager of Product Characterization; George Gray, Manager, Test; Bill McNeally, Supervisor, Test; Bob Frohman, Supervisor, Systems Software Support; Fred Jenne, Director of Advanced Product Development.

"You'd need a wall full of knobs to let them do slowly what S-600 does fast."

"We have yet to find a device we couldn't test on the Sentry 600."

"Field service and support is very good, relatively speaking. Fairchild is the least worst in the industry."

"The thing we hate most about it is the thing we love most about it!"

"Without the Sentry I would never even try to get this type of data."

"One insertion goes through 50 different tests — we are checking parameters, not making Go/No-Go tests."

They know semiconductor testing. And they know the Sentry 600.

The Sentry 600. Just one function-optimized component in the Fairchild Sentry family of six interrelated circuit testing systems.

Optimized for engineering, sophisticated production, and QA/test center operations, the Sentry 600 performs the widest range of tests for the broadest range of components. High speed MOS/LSI, PCB and bipolar testing simultaneously. Complete testing at wafer level and in automatic handlers at full rated device speeds. Finally, and most important to AMI, extensive peripheral choice for massive data generating capacity. Manipulate. Analyze. Compute.

But don't take our word on it.

Listen to AMI: "When we went to buy a system, we could buy anything we wanted. We were not restricted by what the rest of the company had. We made an evaluation and chose the Sentry 600. It lived up to expectations fully."

AMI's experience: It's a good reason to check into Fairchild Sentry systems. Because it's time you had a semiconductor test system that lives up to your needs and expectations.

Fairchild Systems, A Division of Fairchild Camera and Instrument Corporation, 1725 Technology Drive, San Jose, California 95110. (408) 998-0123 TWX: 910-338-0558.

MADE IN FAIRCHILD

Circle No. 22

From the voltmeter house...

Here's how we tested our 42,386th multimeter.

The world's best-selling 3½ digit multimeter is virtually indestructible.

Recently, two Fluke quality control engineers wanted to know if our 8000A 3½ digit multimeter would survive a fall from a 24-foot rack. We were shipping several to a phone company.

So they tossed one out the window. Two stories up. It still worked.

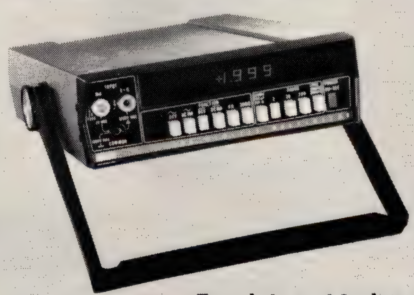
But $99^{44}/_{100}\%$ of these out-of-the-ordinary tests we **don't** instigate.

They just seem to happen.

Our president talks about the time he picked up an 8000A at a trade show without knowing it was ready for case removal. The works crashed to the floor but it still played perfectly . . . to everyone's delight and the president's relief.

One reason why our DMM is so tough: it only has 99 parts. Major analog and digital circuitry are on LSI chips.

It's also flexible. This DMM has 26 ranges, including five ranges of ac and dc volts, five ranges of ac and dc current, and six ranges of resistance. And it's the only DMM using an A-to-D converter with inherent self-zeroing to completely eliminate offset uncertainty.



But it's the ruggedness that really makes the 8000A a conversation piece. Our sales force still laughs about the Fluke salesman who was so hot to make a sale that he took his Fluke multimeter and brought it down—crash!—right on his prospect's desk.

"See," he said, "it's really tough."

And so it was, but the op amp that was hidden under a pile of papers wasn't. P. S.—our salesman didn't make the sale.

On a more positive note, a UPS truck accidentally backed over an 8000A not long ago . . . without ill effect.

So there you are. The world's largest selling 3½ digit DMM. And the toughest. And for $299 it could be yours.

For data out today, dial our toll-free number, 800-426-0361

In the continental U.S., dial our toll free number 800-426-0361 for the name and address of your nearest local source. Abroad and in Canada, call or write the office nearest you listed below, John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe, address Fluke Nederland (B.V.), P.O. Box 5053 Ledeboerstraat 27, Tilburg, The Netherlands. Phone 013-67-3973. Telex: 844-52237. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT, England. Phone 0923-33066. Telex: 934583. In Canada, address ACA, Ltd., 6427 Northam Drive, Mississauga, Ontario. Phone 416-678-1500. TWX: 610-492-2119.

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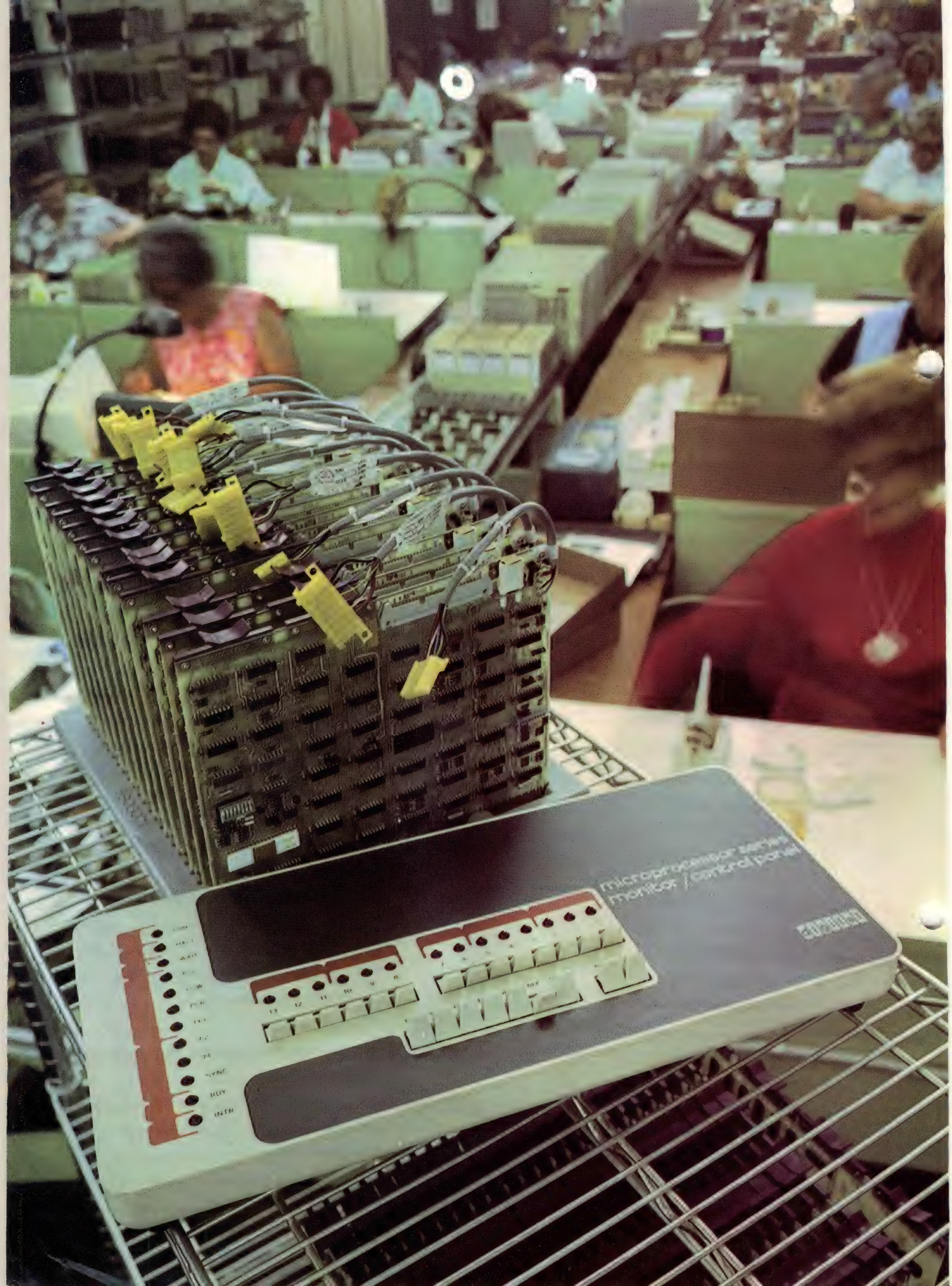
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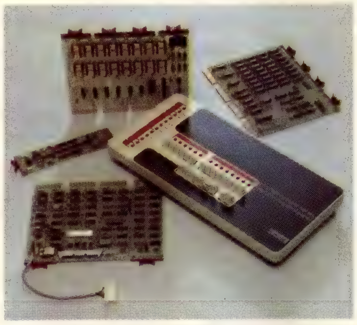


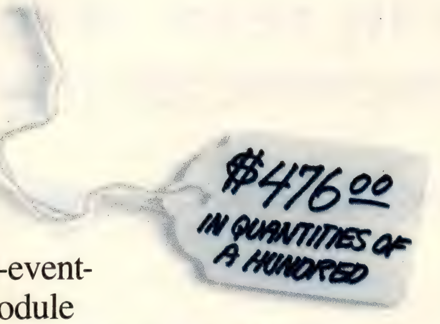
Plus, the MPS is easy to get up and going. Its external circuitry is TTL-compatible, which means you can interface to your computer or controller using Digital's broad line of standard logic modules.

Software development is easier, too. Control programs are prepared on a small, low-cost PDP-8 minicomputer, using the MPS software development kit of six basic programs.

And the modular construction of the MPS allows you to buy only what you need for your application.

Physically, the MPS is a series of four building-block modules and an optional control panel. A basic, fully-operational processor can be assembled from as few as two modules: the CPU and a memory module.

The CPU is an 8-bit parallel processor, employing reliable P-channel MOS/LSI technology. It will directly address up to 16K words of memory; cycle time is 12.5 μsec. Reprogrammable memory (PROM) is available in 256-word increments. Read-write memory (RAM) is available in 1K-word increments.



An external-event-detection module implements nine levels of priority-arbitration. These include application-defined six-level priority interrupt schemes, AC and DC power-failure detection capacity, and the processor-controlled functions of Halt and Restart.

Volume buying will get you a very attractive discount. The MPS is priced at $476 for CPU and 1K of RAM, in quantities of a hundred.

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Fifty years of technological improvement—in one step

Erwin Vodovoz, West Coast Editor

Using CMOS for all digital circuits, a new processor, called a "Polling computer," has been designed as part of a security system by Morse Products of Sylmar, CA.

The need for such a system is apparent. In today's complex world, the inefficient systems of yesterday can no longer be tolerated.

Scarcity and rising costs of copper have necessitated the elimination of new direct-wire dedicated systems by the telephone companies. The techniques used in some of the older systems were being defeated by today's more sophisticated "uninvited guests." Additionally, other functions were wanted that the old systems could not perform. Time and technology finally caught up with the security industry.

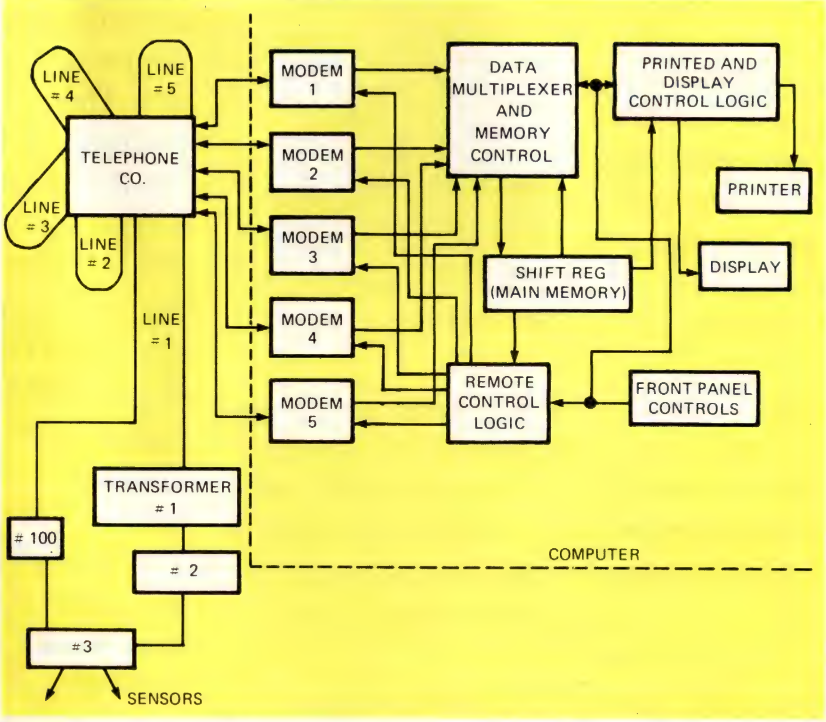

Fig.1—CMOS computing system would seem to indicate high cost. But, because of lower phone line costs, less manpower needed at readout station and multifunction transponders, cost may be actually less than older systems.

Enter 1974 and CMOS

Fig. 1 shows the first major change to take place in this industry in 50 years. Design of the computer was done under subcontract by Technology Service Corp. of Santa Monica, CA. Additional units located in the computer are the modems and a printer (**Fig. 2**).

Why was CMOS used? A prototype unit built with TTL could not meet the U.L. requirement of 48 hrs. of battery operation. "Cooling fans don't like dc" is the way Dr. Earl Swartzlander, Jr. of TSC put it. As a result, the TTL model burned itself up on battery operation. The cooling problem was solved by using CMOS. It reduced the average power consumption for each of the six computer boards to 500 mW. Of that 500 mW, 450 mW are used to drive a green LED on each board to indicate that the board is in an operational condition. Continuous self-testing is part of the system in order to provide the necessary reliability.

Largest power drain in the system is the paper advance mechanism. It draws 60W for 40

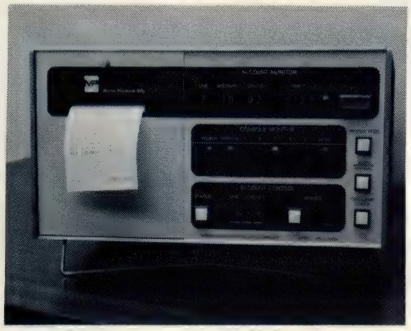

Fig.2—Flexible operation is obtained with few controls on the computer. These controls allow acknowledgement of a problem, computer check, status check of all units, and remote control operation of facilities of the trouble site.

msec. That's not as bad as it sounds because the printer only runs when there is a problem or when a status check is made.

CMOS is used again for all digital circuits in the transponder at the other end of the system (**Fig. 3**). A 500 mA/hr battery is all that's needed to power this unit for the U.L. required 48 hrs. Normal current drain is only 10 mA, including the unit's voltage regulator, modem and memory, counter and transmitting circuits.

Putting it all together

How does it work? "Very well" is usually the kind of answer you'll get from Mike Winestock, president of Morse Products. Because of the nature of the system, many performance parameters are confidential, such as frequencies, pulse widths and pulse codes. However, the following information has been revealed.

Each of the five modems in the computer can handle up to 100 transponders. All modems feed the computer logic circuits in parallel. Going in the other direction, the modems interrogate all 100 transponders sequentially in less than 23 sec. If a transponder indicates a change of status or a problem, the computer acknowledges and interrogates a second time to verify that a true problem exists. After transponder verification of a problem, the computer produces a printout.

The balance sheet

On the plus side, because this system uses gated audio frequencies, a dc line is not needed. In fact, one of the first security systems to be installed will use a microwave relay link.

The system can handle up to 500 transponders. Maximum capability of previous ones was 45. Since it can accommodate so many more customers and can handle multiple functions (fire, breakin, hold-up, etc.) with one transponder, final costs may be comparable with the older systems.

The techniques used by this system make it very unlikely that someone can defeat it. An intruder would have to break into a line in seconds with exactly the right frequencies and pulse widths—a very difficult task at best.

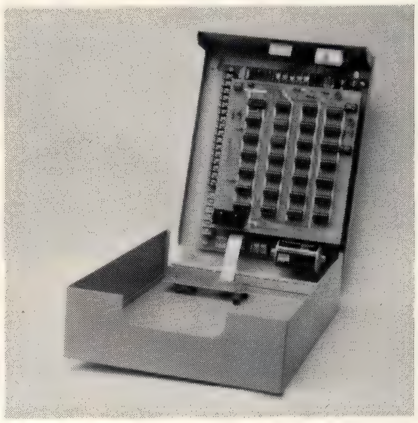

Fig.3—Transponders have 75% of components on plug-in board for quick repairs. CMOS circuitry permits a small Ni-Cad battery to supply all power required for 48 hrs. of operation.

On the negative side of the balance sheet, there does not appear to be any entry yet.

Cost, ease of use and flexibility are all on the side of this new system. Only time will prove if the equipment is as reliable as needed and as foolproof as it seems.□

One small microprocessor chip equals one giant step for industrial camera systems

It's a rare engineer today who hasn't at least considered the possibility of designing a microprocessor into his company's products. One of the latest results of such thinking is an industrial camera system dubbed the "smart camera" by its manufacturer, Reticon Corp., of Mt. View, CA. The *smart*, of course, comes from the inclusion of a microprocessor—in this case the Intel MCS-4.

Traditional industrial camera systems are used for noncontact inspection, process control, and size and position measurements. Although they are quite versatile in the *types* of applications they can be used for, they have a limited measurement and control capability in any particular application because of their hard-wired controllers. Use of a microprocessor-based controller, with its inherent software programmability, removes most

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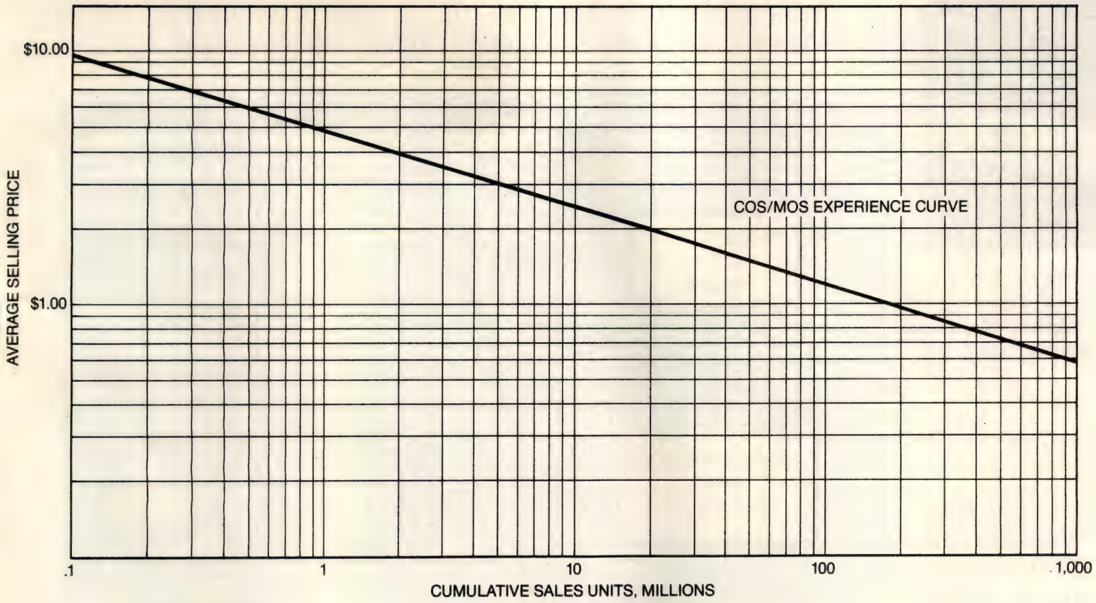

But there are more benefits from the RCA learning curve than volume and price. There's advanced circuit design, meticulous control of quality, the offering of the broadest choice of functions and in-depth applications support.

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For example, we've recently reduced prices of plastic, commercial ceramic and chip versions of standard COS/MOS by an average of 15%. Popular MSI types have been reduced by as much as 20%.

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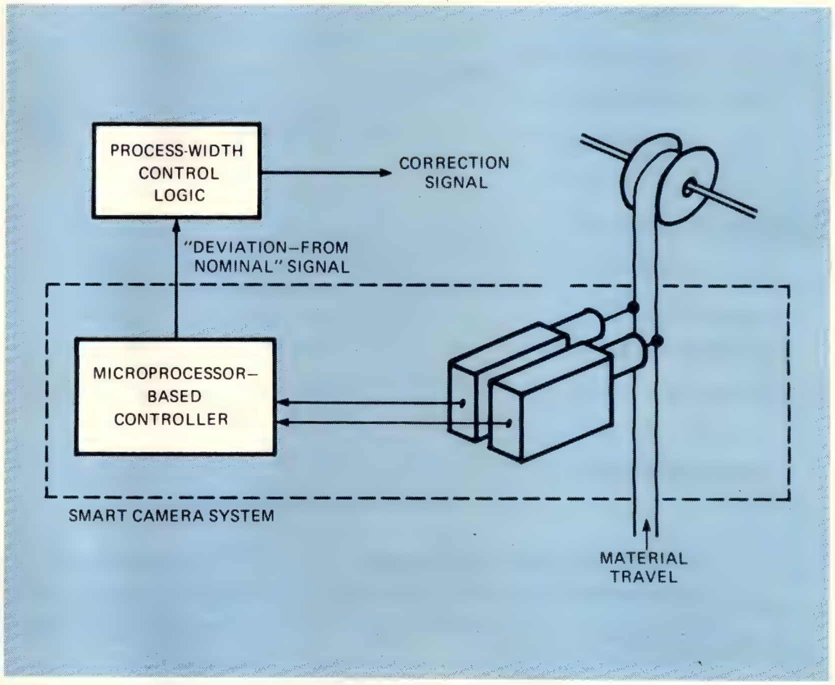
Circle No. 24

The "smart" camera system consists of a solid-state line-scan camera, a microprocessor-based controller and a standard teletypewriter for program control and printout.

of these limitations. It also adds a high degree of computational capability, as well as the ability to store the results of many measurements and read them out at an appropriate time.

In its simplest form, the Reticon camera system will inspect parts passing through the camera's field of view and display their dimensions in engineering units (inches, mils, etc.). It can be programmed to segregate measured parts into 10 different categories and provide relay closures for their automatic binning. The system also compares its measurements to desired tolerances that are programmable, and gives pass/fail indications.

This "smart camera" system keeps records of measurements taken and the distribution of parts and tolerances. On command, it can provide a printout of a day's *production* on a standard teletypewriter.—*FE*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Data from two cameras can be processed with the "smart" system. For example, the width of a continuous sheet of material can be monitored by using a separate camera to look at either edge of the material. The controller then continuously calculates and updates the deviation from nominal width.

Here's your chance to learn how to write for publication

If you want to write for EDN or other technical publications, but don't really know the ins and outs of getting into print, here's your chance to find out what the editors want and how they can assist you. Engineers, engineering managers and marketing managers with information of value to their colleagues or potential customers can get the publishing know-how to communicate this information at a 1-day seminar entitled "How to Write for Publication."

Sponsored by Boston University, the seminar will feature our editor and the editors of about 10 other Boston-based technical publications. The editors will explain how and why they select articles for their feature, product and news sections; gives guidelines for publishing articles in their publications; and meet with each registrant individually to further discuss publication requirements. Your time won't be wasted with textbook discussions and grammar, sentence structure and style. Instead, this seminar will provide you with practical, hard-core details.

Scheduled for Thursday, Oct. 10, it will be held at Boston University's George Sherman Union. Registration fee of $75 includes lunch, dinner and all materials. Make checks payable to Boston University-SPC and send them to Gary Wolfe, Science Communication Division, Boston University School of Public Communication, 640 Commonwealth Ave., Boston, MA 02215. The seminar is sponsored by the graduate Science Communication Program in the Journalism Division of Boston University School of Public Communication.—*CL*

TIPI computerizes Air Force tactical operations

A military data storage and retrieval system contains one of the world's largest mass memories ever developed for use in a tactical environment. Demonstrated by RCA for the U.S. Air Force, this Display Control/Storage and Retrieval (DC/S&R) segment comprises part of the Tactical Information Processing and Interpretation (TIPI) system. It is used in the support and command of air and ground forces in combat.

Ruggedized and ready

Packaged in mobile, transportable shelters, the system provides field commanders with all the mission/support hardware, software and personnel needed for processing image and nonimage intelligence data. This segment handles intelligence gathered by sources ranging from verbal reports to data collected by highly sophisticated, multi-sensor reconnaissance aircraft.

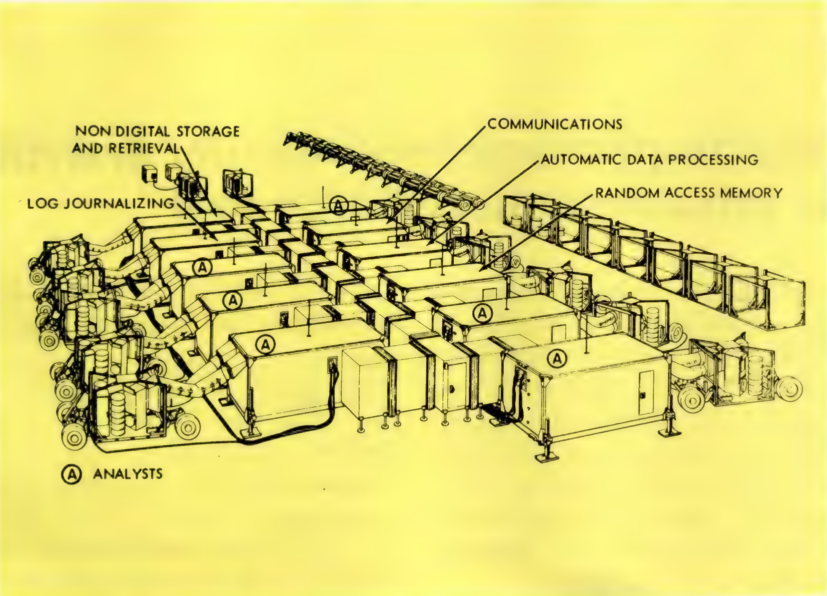

Fig. 1—TIPI DC/S&R Segment land-based equipment can be transported by mobilizer, truck, helicopter, aircraft and ship.

Analyst stations

One of several computerized intelligence analyst display stations (23 stations are provided) is demonstrated. Provided with a Query Response Unit (QRU), each analyst can draw on all categories of information from

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U.S. Patent 3,701,932

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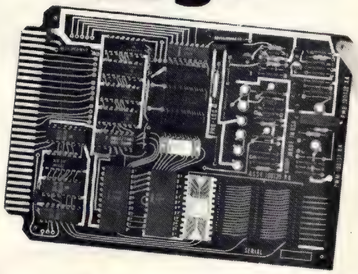

Our 4-bit microprocessor system can replace a rack full of your TTL chips. You'll save design time and production costs. No big redesign jobs for options or changes because the logic is stored in reprogrammable ROMs. Our programmed logic systems are available now, off the shelf.

Our PLS-401 microprocessor system costs less than $400 in a quantity of one, with substantial OEM discounts. Plus we've got all the support you need: Design manuals, 2-day intensive design course, ROM Programmers, System Testers, special interface cards and support hardware to make your system go together smoothly.

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the huge 2.5 billion bit data bank.

Heart of the computer system is the AN/UYK-7 minicomputer supplied by Univac. Its mass memory RAM shelter houses two magnetic drums and six disc units designed by RCA.

Hardware integration of the DC/S&R segment of TIPI was performed by RCA from their Burlington operation.—*CD*

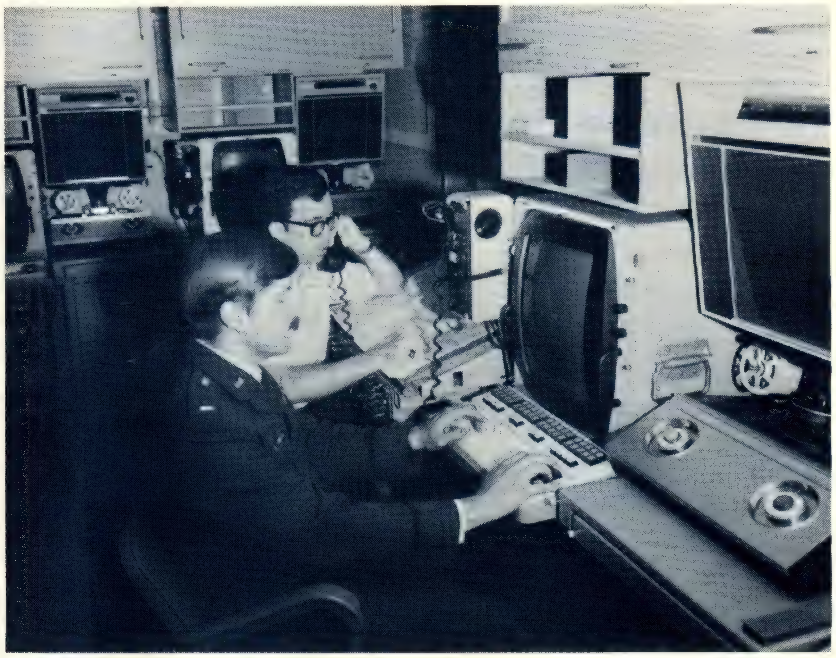

Fig. 2—Motorola's Total Scope II CRT display provides this analyst with 3-mode editing and keyboard control of 4000 displayed characters. A 40-key entry allows instant selection of firmware from a library of pre-formed messages.

Spectrophotometer-computer system is valuable food research tool

Did you ever want to know the fat content of ground beef or the firmness of a seemingly perfect apple? For the right price you can. A scanning Spectrophotometer coupled to a computer, nondestructively locates characteristic wavelengths of practically all agricultural commodities.

The Spectro/Computer, available from Neotec Corp., reaches optical densities of 9.0 (10^9 intensity level ratio) and scans from ultraviolet to visible to near infrared. Bandwidths are from 1Å in the ultraviolet to 3Å in the infrared. A computer, with extensive built-in software, enables rapid investigations of transmitted or reflected energies.

Designed for simple operation, the unit was developed under the direction of Karl Norris at the U.S. Department of Agriculture, Athens, GA. The operator places the sample to be tested in the allotted holder. After describing the scan desired, a CRT or hardcopy displays the analysis in seconds. Some areas of testing are firmness, taste, shelf life, protein, oil and disease growth. The programs can be extended using either BASIC or FORTRAN languages.—*JA*

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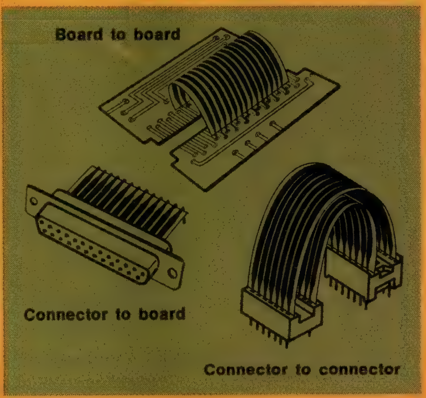

Interested? Just circle the reader service number for your ANSLEY BETTER WAY CONTEST entry kit. It will detail the rules, provide complete technical information and FLEX STRIP® jumper samples, plus a list of typical applications. All we need are new ones! Even if you're not interested in our contest, send for the package, our application drawings may solve an interconnection design problem you're working on. (Employees of Thomas & Betts Corporation, its subsidiaries, agencies & distributor salesmen are not eligible for prizes.)

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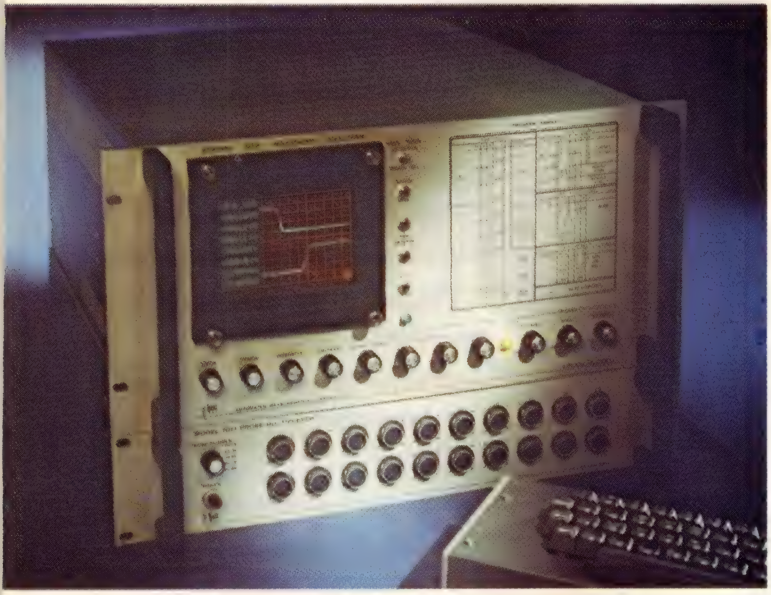
PhD II—What does it take to earn an Intelligent Instrument degree?

Intelligence is a relative quality. As applied to instruments, its definition can be elusive. Here's a guide for measuring it.

Martin Marshall, E-H Research Lab., Inc.

What is intelligence? If lithium niobate molecules arrange themselves into a local decrease in entropy called a crystal, if a single-celled euglena wiggles its way to sunnier water, or if a child dreams of unexplored worlds, they all have exhibited some form of intelligence. Clearly, to talk about intelligent electronic instrumentation in a rational fashion you need some criterion by which to detect or measure intelligence.



The AMC 1010 is a 1-GHz dual-trace sampling scope that combines digital readout, program display and a fluency in ASCII. It is used for computer-directed fault diagnosis and monitoring of up to 100 test points within a system, or can be used manually. With an accuracy of 1% of F.S., it spans ranges from 0.2 nsec/division to 100 msec/division.

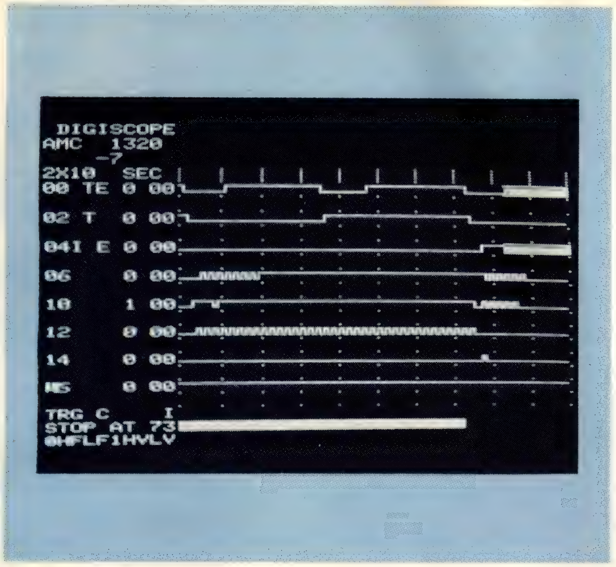
In the biological world, these criteria are the answers to a set of questions that might well be asked of electronic instruments. They are:

- Does it have an instinct for self-preservation?
- Is it aware of its environment?
- Can it remember its experience?
- Can it interpret its experience?
- Can it make decisions on the spot?
- Can it express itself?
- Can it communicate with another intelligence?
- Can it understand the problems of others?
- Is it sure of its sensitivities and judgement?

When the answer to at least one of these questions is yes, then you have an instrument with some kind of intelligence. Some of the paths that instrumentation has taken in order to achieve "yes" answers are:

- Over-voltage protection
- Measurement sensitivity
- Local memory
- Arithmetic capability
- Real-time response
- Digital readout
- Programmability
- Fault diagnosis
- Self-checking capability

Several of these capabilities have been around for a long time, but only became common in instruments as the switch from analog to digital measurement techniques prevailed. Others have



The 16 traces of the E-H AMC-1320 logic analyzer show such analog information as ringing (channel 10), a higher ZERO and a low ONE (channel 12) or a glitch (channel 14), in addition to a display of logic states.

been made cheaper and easier by the advent of LSI and μP's. Add to these advances the arrival of "firmware" in data acquisition systems in the form of interchangeable pROM's and it becomes clear why so much "intelligence" is being packed into today's instrumentation. Let's first look at where we've been. Then we'll examine the recent progress of these features.

Evolution—from DVM to logic scopes

From the first DVM introduced by Non-Linear Systems, Inc., back in the early fifties to the first sampling scope introduced by HP in 1961, to the Tektronix storage scope in 1965 and spectrum analyzer in '70, to the Boonton self-balancing capacitance bridge in 1973, and finally to the logic scope of 1973-74, instrumentation has taken on the responsibility of processing the information that used to be left to the operator and his computer, if it was possible at all. Now thanks to LSI, microprocessing, local memory and just plain human engineering, these instruments have come alive with their own languages.

They protect themselves to some extent and feature restricted operator participation. They often tell the human operator when he has made a mistake, and can often indicate their own failures—to a limited extent—to him. Schooled by iteration, these instruments adjust themselves accordingly, as with feedback loops of stimulus and measurement modules. And they do acquire and process incredible amounts of information at speeds that are humanly impossible.

These improvements have permeated the field of instrumentation, advancing somewhat in stimulus modules but largely in monitoring and measurement modules. They have elevated the calculator to the status of a small computer and added new dimensions to the oscilloscope.

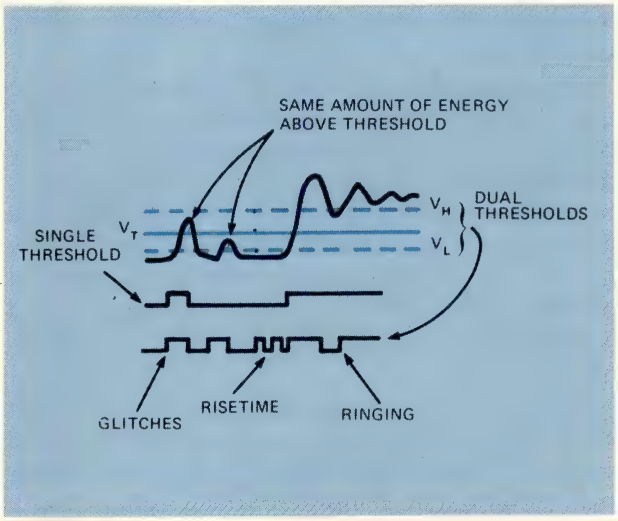
Self-protection leads to long life

Mistakes and component failures are bound to happen, and an instrument that can survive quick changes in its environment has a much higher chance of a long, useful life. For most instruments this protection is simple; some kind of voltage-damping circuit at the input or a current-sensing circuit in the power leads to effectively disconnect its circuitry during a voltage or current overload.

Some instruments attempt to avoid failure by use of redundancy. Such is the case where a decision is based upon the output of three parallel sensors, with the majority ruling. This way, if one circuit fails, the functioning of the instrument continues and a warning flag is sent to a processor or LED. The trouble with redundancy, though, is expense, for it costs more to make three of everything. However, if that extra cost is outweighed by the cost of downtime on the system, then it is justified.

Fault diagnosis moves ahead slowly

A truly intelligent instrument should be able to determine its own faults, and then be able to compensate for them. Unfortunately, at this stage of technology such an instrument is seldom practical or even feasible. Some progress has been made, however, in indicating to a user various setup or even hardware discrepancies.



Using a dual-limit rather than a single-limit comparator in the E-H AMC-1320 logic analyzer yields such analog information as rise times, low ONE levels, high ZERO levels, ringing and positive or negative glitches. As displayed, a single threshold scheme cannot retain any risetime information and can only detect large glitches.

For example, some oscilloscopes have an indication on the CRT that tells a user if the probe that is generating a given trace is ungrounded. If you mix up the starting and ending points of a time or voltage measurement on some sampling scopes, the digital readout (DRO) indicates the error by putting a minus sign in front of its measurement display. Several pulse generators have the feature that no matter what the instrument setting is, the pulse generator will be protected. Another feature is if an illegal setting is used, such as a pulse width longer than the period, the instrument will "count down" pulses (i.e., generate every other pulse).

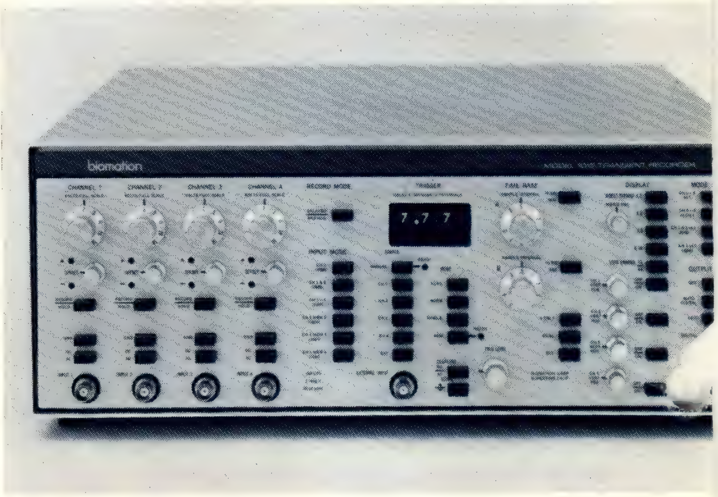
Ideally, fault diagnostics can be built-in even at the most elementary level. LSI wafers, for example, are currently being designed with built-in-test features such that if the entire IC is working, the voltage on one lead will remain at a specified level. If this can be done for LSI IC's, then it can be done for instruments and systems. But technology hasn't reached that stage yet, so fault detection instruments are still necessary.

GO/NO-GO tests can be complex

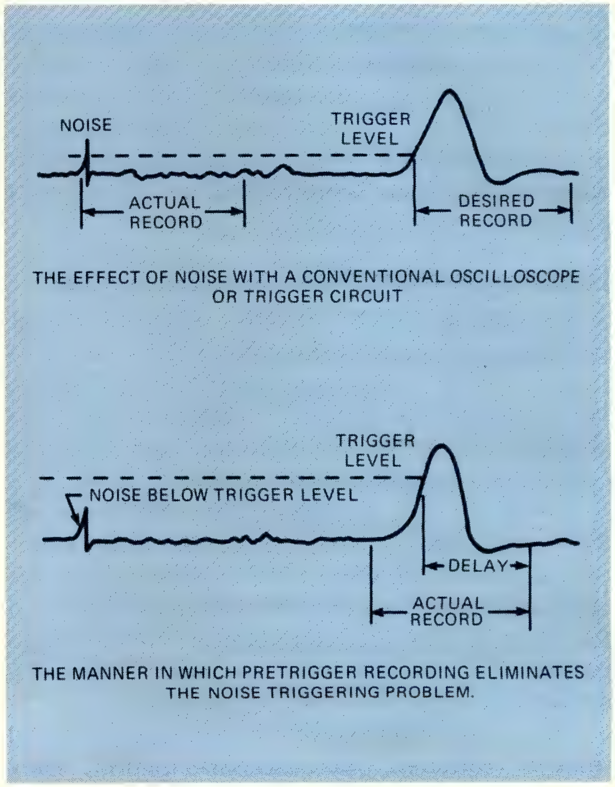
Fault detection is most important at the system level, where one instrument is assigned to monitor and diagnose the rest of the system elements. Naturally such an instrument has to monitor quite a number of key points, whether the system be an LSI chip or a satellite tracking station.

One approach to this kind of monitoring is to use a programmable sampling scope with 100 probes tied to the system computer or to a programmable calculator. Although these scopes have memory for program and current data information, they would still require analysis by the CPU (GO/NO-GO paths) and then some sort of fault dictionary in order to spit out such a sophisticated diagnosis as "Replace Q_{12} in module 14."

You can get an idea of how complex fault diagnostics can become by noting that testing a single LSI chip may require a half-million dollar test system. On a more practical system level, however, the answer is a programmable form of the new logic scopes that have burst onto the marketplace in the past year. Such an instrument continuously monitors an operating system and triggers on the system fail flag. Its pattern of ONE's and ZERO's on, say, 16 key traces is then dumped into the CPU and compared with the standard pattern stored in disc. If that pattern checks, the CPU runs through a fault dictionary. This switches the logic scope probes to new points in the system, and instructs the scope to trigger on a new set of logic states corresponding to the suspected fault. In this way a CPU program closes in on the most minute fault in the most complex of systems.



The Biomation model 1015 waveform recorder converts an analog signal to digital data and stores it in a digital memory. Utilizing four A/D converters with 10-bit resolution and a 4k 10-bit word MOS memory, it digitizes and stores signals up to 25 kHz. Data output is by selection: digitally, or analog, fast for your scope and slow for your pen-and-paper recorder.


NOISE
TRIGGER LEVEL
ACTUAL RECORD
DESIRED RECORD
THE EFFECT OF NOISE WITH A CONVENTIONAL OSCILLOSCOPE OR TRIGGER CIRCUIT
TRIGGER LEVEL
NOISE BELOW TRIGGER LEVEL
DELAY
ACTUAL RECORD
THE MANNER IN WHICH PRETRIGGER RECORDING ELIMINATES THE NOISE TRIGGERING PROBLEM.

Unique capability! It has the ability to record the signal preceding the trigger point. This "pretrigger recording" feature ensures recording of the leading baseline and rise of a signal.

The operative word in such a near-idyllic setup is "suspicions." Suspicion is a type of intelligence requiring both memory and data process. The only limit to this kind of fault-detection is the system engineer's experience in describing suspected faults, knowing what points to examine and what to trigger on. A dictionary of these suspicions gives the instrument the electronic equivalent to animal instinct. What it does not give the instrument is true creativity, the ability to envision a totally new type of failure requiring a new trigger pattern. For that the human operator must examine a CRT.

Consider measurement sensitivity

Somewhere between the noise level and the breakdown voltage of a sensor is the valid measurement spectrum for intelligent instruments. Regardless of the property they measure, they should have one feature in common, autoranging. These instruments will then automatically select a measurement range appropriate to the unknown magnitude. This will require more sophistication than the automatic gain control (AGC) used in the RF field.

In our case, the digital instrument must "know" enough to inhibit measurements while changing ranges. Starting at the highest range (minimum sensitivity), it then increments to one on which the input signal is a given fraction of full scale.

Sometimes, however, you are not afforded the luxury of having repetitive waveforms to measure. If you want to observe transient parameters, you must use instrumentation built around the philosophy: "Genius is doing it right the first time." These are the single-shot measurement modules that have become popular as the switchover to automated systems has taken place.

Unlike oscilloscopes that require many passes of a given waveform in order to build up a display, single-shot time and voltage modules must capture the desired information using only a single stimulus. This quality is duplicated by storage scopes, but limited to a bandwidth of 100 MHz as opposed to the over 1 GHz of the single-shots.

In IC testing for example, it is often important to examine the first pulse that comes out of an untested device. The pulses emitted before a device has heated up can be the cause of subsequent system failures. This fact, coupled with the ability to make measurements five to 10 times faster than oscilloscopes, has led to the inclusion of single-shots in many automated systems.

Digital readout cuts human error

From the first digital voltmeter (DVM) introduced in the early fifties, the idea of digitizing a measurement has been to eliminate the human error factor. Instead of squinting into a panel meter in an effort to avoid parallax errors, one simply reads numbers off the display. The advantages of DRO are readily apparent in DVM's and DMM's. Now oscilloscope makers also find them a great advantage, so much so that new Tektronix and HP models have some form of DRO.

The logical place to begin is with sampling oscilloscopes, where quantized grids fix the time relationships of dots on the scope's trace. Once the dots are quantized, it's a short step to digitizing the voltage of each dot. Finally, the scope's electronics display the desired time and voltage difference measurements as alphanumeric characters on the CRT. The first such scope was the Tektronix 567 introduced in 1963. Its inventor then formed Automated Measurements Corporation in 1964 and produced a line of programmable sampling scopes with DRO.

Microprocessor-controlled bridge computes and displays 1-MHz capacitance and loss. Designed by Boonton Electronics, model 76A is fully programmable and features autoranging, storage, digital readout and ASCII data output.

The scopes were an instant success, as one AMC salesman relates. "We used to go into a factory and see scopes with masking tape or grease pencil lines on the CRT to mark off acceptance limits on a QA measurement. Our accuracy was 2% with the DRO, but the best they could do with the analog scope was about 5%. With the acceptance limits marked so crudely, they often wound up with 10% errors, simply because the human eye was part of the measurement system."

The usefulness of DRO goes far beyond letting the electronics do the squinting, however. In formatting the measurements into digital signals, designers were preparing these *instruments* for the second plateau of intelligence, programmability. For you see, a digital signal can be sent as easily to a controller as it can to a DRO.

Programmability means intelligence

Just as one of the first signs of intelligent man was his ability to communicate with other men, so is an instrument's capability to communicate with another a mark of its intelligence. Until recently the prime communicating instrument was a computer, but now programmable calculators have been upgraded and compete for minicomputer applications. In addition, other instruments have added memories and arithmetic capabilities, and now store their own programming locally (firmware).

Take, as an example, a programmable sampling oscilloscope with DRO. It receives programming instructions from a keyboard or controller and stores them in local memory. Next, it makes a time or voltage measurement and stores that in local memory, too. Both its programmed settings and DRO are displayed on a CRT screen shared with the measurement traces. This the local memory allows it to do without communicating with a computer. In other such instruments, either present or next generation, reprogramming the instrument is done entirely in firmware using pROM's.

Another advantage of programmability is that it allows an instrument to learn through feedback. A controller can program a pulse generator, for example, to produce certain pulses. The ones that result can then be monitored by a programmable scope and fed back into the controller. The controller compares the results with its expectations, and, based on this, issues new commands aimed at producing a closer approximation of the desired pulse. These feedback programs can also be used for self-diagnosis of a single instrument, or for several instruments in a system. The operator simply runs a tape that exercises all the functions and ranges of an instrument and then compares the measured output with expected values. The same can be done for measurement instruments using known stimuli.

Processing is super intelligence

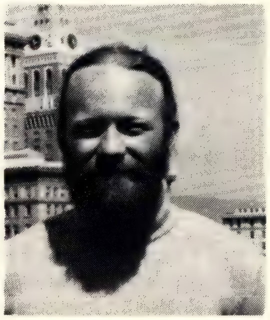
Local memory provides an instrument with the ability to perform arithmetic manipulations of its measurement data without the need of a computer. A scope, for example, with some form of local storage can count the number of time intervals between one voltage on a waveform and another, and then display its calculation on a DRO. Another can multiply the voltage of one trace by that of another and display the resulting trace. This convolution of two traces or even a transformation from time to frequency domain is made possible by adding arithmetic capability to an instrument.

Local memory also allows for the creation of an instrument that can retain data received immediately *prior* to a given trigger signal. This feature has given rise to a new class of instruments called logic scopes or logic analyzers. Such instruments trigger on a malfunction and display the data acquired a certain number of bits both before and after the trigger event. In so doing they exhibit a form of intelligence that few animals attain, truly simultaneous reception of information from many sources (up to 16) on a real-time basis.

Beyond this, such an instrument exhibits yet another mark of intelligence, the ability to selectively respond to stimuli. In these instruments, that ability takes the form of Boolean combinatorial triggering. Boolean triggering is the triggering of the instrument on the desired combination of ONE's and ZERO's of the input data. One may recognize a fault as having ZERO's on the first five traces and ONE's on the next three, for example. The gating logic within these instruments makes the Boolean triggering possible, but the "look back" feature would be impossible without local memory.

In the next generation, with LSI containing built-in test features, the ability of intelligent instruments to pinpoint not only their own faults but a system's as well, will enable them to indicate the smallest errors in the largest systems. Then the next step will be to get them to solve problems for which there are no analogs, using methods for which there are no precedents. Such an instrument would be not only intelligent, but creative. □

Author's biography



Martin Marshall is a senior writer for E-H Research. He was formerly an assistant to the Science editor of Newsweek magazine and in 1971 was the editor of the New Engineer magazine. He received his BS in physics from Caltech where he did research on NAS & AEC projects. Having found chess a bit slow, Martin now has time for acting and singing with a blues band in San Francisco and Berkeley theaters.

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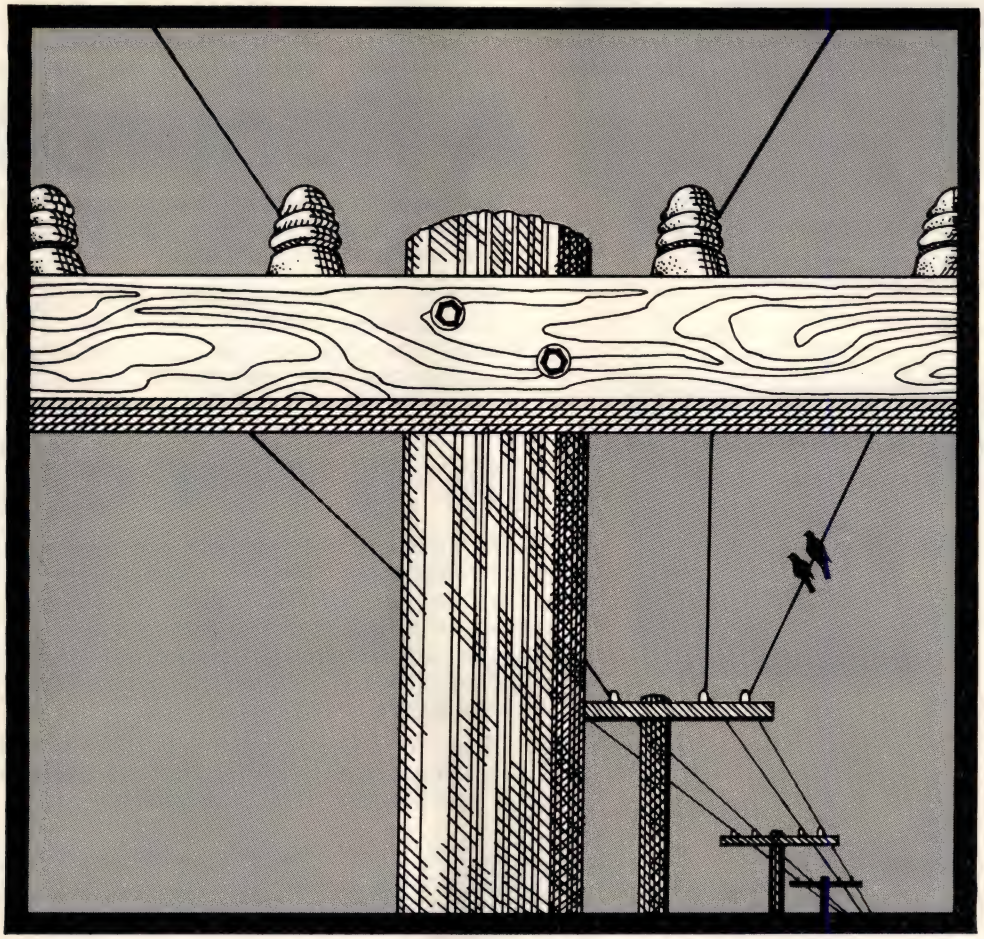

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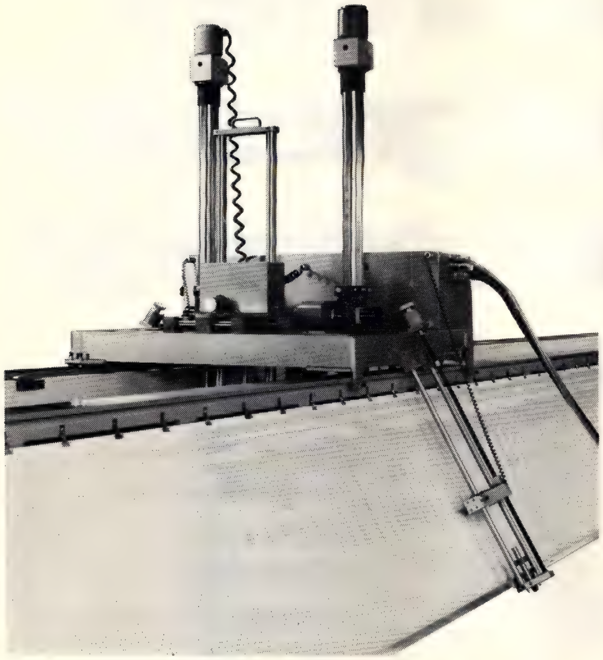

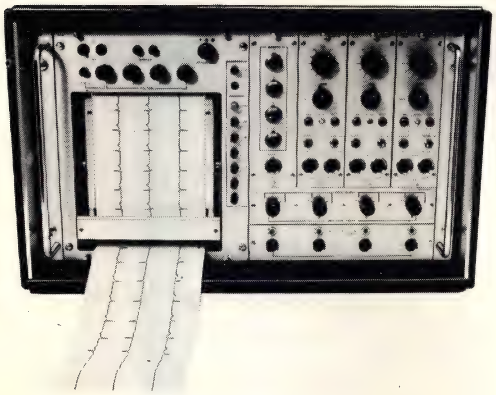

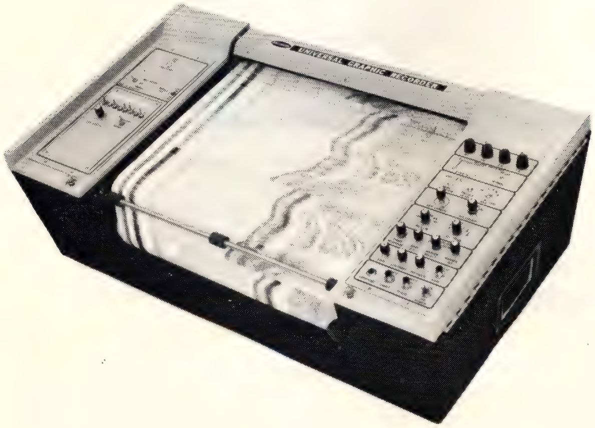

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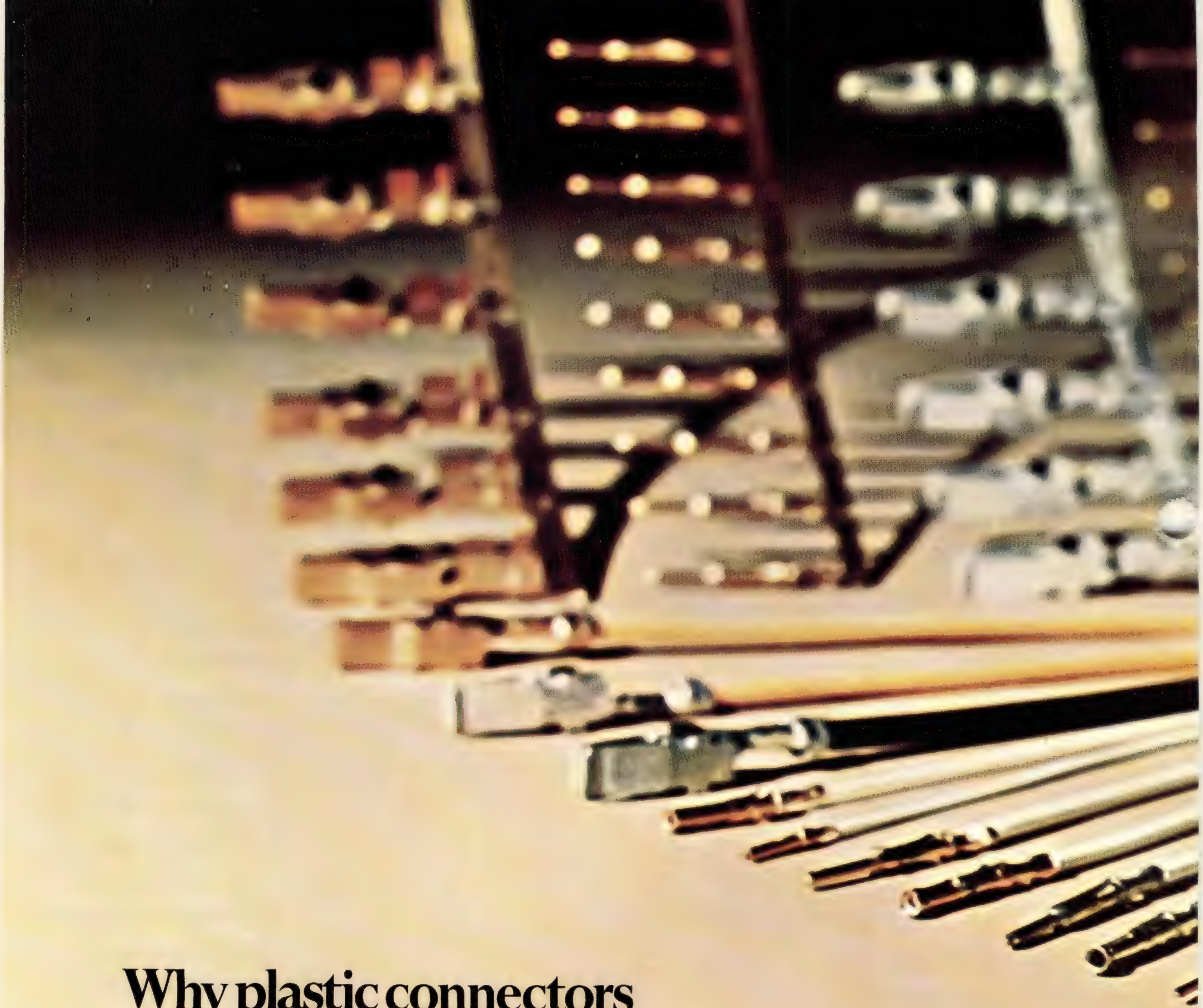

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Circle No. 29

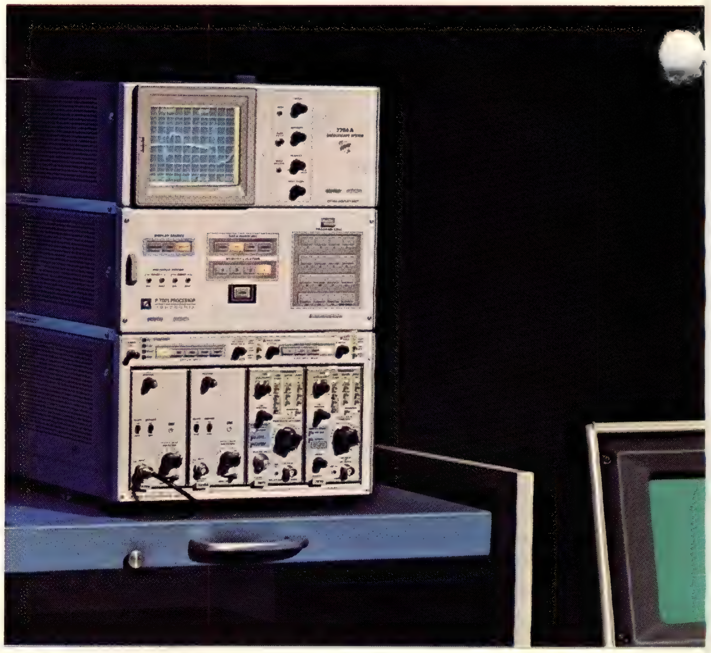
Today's system concepts demand instruments be made intelligent

Microsystems from LSI technology can enhance data acquisition, processing and display functions.

Bruce Hamilton and **Luis Navarro**, Tektronix, Inc.

Advances in technology, particularly over the last decade, have resulted in a tremendous increase in the complexity of electrical measurements and instrumentation. Electrical signals increased significantly in bandwidth and information content. New instrumentation designed to measure these signals faced demands from the users that it be more accurate and versatile. To a large extent instrumentation **did** become more accurate and versatile. However, as a result of trying to meet all these requirements, instrumentation also became more complex to operate and often less reliable.

Fortunately, the same technology that was causing instrument designers these problems was beginning to provide some solutions. Small and medium-scale integration improved reliability, while LSI promised even more improvement. Integrated logic brought minicomputer prices tumbling down and put more of them on the market. As quickly as mini's began to appear, they were used in instrumentation, providing a means of increasing the capability of instrumentation while simultaneously simplifying or even automating its operation. This initial application of intelligence to instrumentation proved so beneficial that a major trend was established.



Any displayed signal can be digitized and processed by the Tektronix Digital Processing Oscilloscope. Over 30 plug-ins give the DPO unmatched acquisition flexibility. Signals from µV to kV in amplitude, from psec to sec in duration and from dc to 14 GHz are made available for analysis.

Instrument functions identified

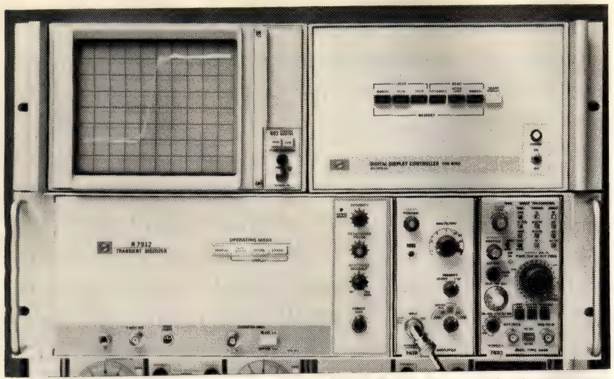
Most measurement instruments divide into three functional sections: acquisition, processing and display. These basic functions can be identified in instruments ranging from a simple VOM to a complex laboratory oscilloscope. For example, in the VOM, the probes are the acquisition section; the internal resistive dividers, the processing section; and the meter, the display section.

With a more complex instrument such as an oscilloscope, again three sections exist. The probes are definitely in the acquisition section. (Dedicated probes may be used to adapt the scope to the signal being acquired.) Some scopes have plug-ins that may also be considered as part of the acquisition section. In such cases, the acquisition process can be optimized merely by changing plug-ins. An oscilloscope's internal amplifiers, delay lines, etc. form the processing section, while the CRT is the display section.

The trend today is to make measurement instrumentation modular. Most modules perform one or two of the three functions. An example of this in a digital voltmeter is the H-P 3470 Measurement System. Several modules combine the functions of acquisition and processing. A separate module is used for the display function. Another example is the Tektronix Digital Processing Oscilloscope (DPO), where the acquisition, processing and display are all separate modules.

What is intelligence?

Webster's Dictionary defines intelligence as "the capacity to apprehend facts and propositions



Before very fast transients can be studied in detail, they must be captured. The Tektronix R7912 Transient Digitizer in waveform digitizing instrument configurations is designed specifically for high-speed signals. Using a CRT scan converter, it provides a visual writing rate of 30,000 divisions/µsec or a digital stored writing rate of 8000 divisions/µsec. This instrument accepts fast single-shot or repetitive signals and converts them to slower analog or digital signals.

and their relations and to reason about them." However, this definition is not exactly applicable to our discussion. Hence, the following definition is proposed: "Intelligence is the ability to accept instructions and facts (data) and then carry out these instructions, with decision making based upon the facts."

Being structured to accept instructions and make decisions (conditional branch instructions), surely mini's and programmable calculators qualify as leading candidates. Our definition also embraces other calculator and computer-like structures that accept instructions and make decisions.

To help clear up some of the gray area between intelligence and nonintelligence, keep in mind that there will be structures with intelligence constrained. That is, the intelligence is there, but can't be used. If the intelligence is dormant or currently unused, the instrument cannot be judged intelligent.

Acquisition with intelligence

A frequent demonstration of intelligence in the acquisition function is in the recording of signals or readings on a magnetic tape, disc or paper tape. Here, controlling of recording equipment during search, read, write and rewind operations requires intelligent decision making as well as special 3, 8, 12 and 16-bit formatting.

Front panel simplification by eliminating the need for some *manual* controls is another manifestation of acquisition function intelligence. One example is the automatic selection and display of the correct attenuation for an input signal. This is generally known as autoranging, and may include a means of incorporating complex criteria for range selection based on input signal parameters. However, autoranging may not be feasible under certain conditions. One is failure to acquire the input signal or its parameters; the other is an override command from an external source such as a keyboard.

More accurate signal acquisition is made with very precise signals presented to the acquisition section for either self test or for comparing with the input signals or readings just acquired. Differences represent errors and can be stored and used to correct future readings. When the computation and use of correction factors is done automatically, you have automatic calibration or "autocal."

Processing with intelligence

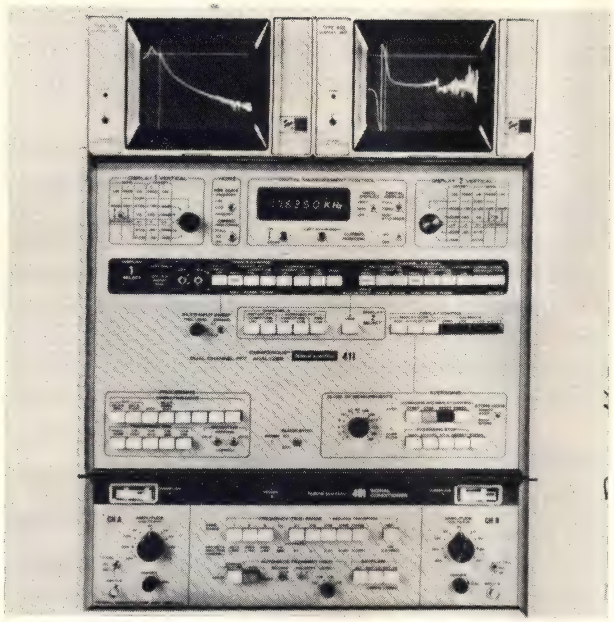
Advanced digital and numerical techniques now make it economically feasible to employ the intelligence of a minicomputer to process signals formerly handled by analog circuitry. Some of the resulting benefits are:

- More precise processing
- More versatility in processing
- Processing not limited by time and BW

More precise processing. The precision of an intelligent device such as a minicomputer or programmable calculator usually ranges from four to 12 decimal places. If proper precautions are taken, the numerical errors introduced into calculations can be held to one or two decimal places. As a percentage of 12 decimal places, these errors are far less than the best tolerances available in analog components.

Interchangeable modules are featured in the H-P 3470 measurement system 4-digit DVM. With its "snap-together" expandability, changes in measurement needs are readily accomodated.

However, the reader should be made aware that precision does not always mean accuracy. Accuracy is an absolute thing and the results of processing cannot be more accurate than the original data. This problem is realized when a signal must be digitized for processing. Current-



The OMNIFEROUS™ FFT Analyzer Model OF-400 is a dual hi-speed FFT processor. It operates like an instrument and calculates like a computer. Supplied by the Nicolet Scientific Corp., it enables a user to observe transfer function, cross-spectra or coherence as the signal is changing, without waiting for the analyzer to perform successive laborious calculations.

ly, the techniques for digitizing produce accuracies much less than the 12-place processing precision mentioned earlier.

Analog-to-digital converters (A/D) available today are a trade-off between speed and accuracy. Their accuracy limitation is basically determined by noise introduced by the A/D circuitry. For example, 14-bit (4+ decimal places) A/D converters are available; however, they convert so slowly they may have to be combined with samplers to be able to digitize the majority of electrical signals. As a result, some fast single-shot signals cannot be converted by a 14-bit AD converter.

More versatility in processing is available through the use of intelligence. As an example, consider the Tektronix DPO processing section. It performs the following processing functions:

- RMS, average waveform measurements
- Addition, subtraction, multiplication and division between two waveforms, or a waveform and a variable
- Integration, differentiation
- Signal averaging
- Fourier and inverse fourier transforms
- Convolution, correlation
- Probability density functions

Normally several different instruments are required to do all the above operations. On the other hand, configured with BASIC programs, the intelligent DPO, unassisted, runs the above functions. Thus, it acts like several instruments controlled by a computer. That's versatility!

Time and bandwidth do not limit the processing function implemented with intelligence. On the other hand, they do limit very severely processing employing analog circuitry. As an example, consider the integration of a signal with op amps. It limits at several tens of kHz. Discrete components will up it to several tens of MHz, but what can you use at several GHz? The answer is to digitize the signal by intelligent means. Integration will then become independent of bandwidth and be available for calibrated displays and other processing.

Display with intelligence

Perhaps the finest examples of intelligence, combined with the display functions, are the so called "intelligent terminals." Configured with many routines, they use memory freely to periodically refresh alphanumerics and graphics. With it you can scale, rotate, window and translate the display. Thus, intelligence can make the display more meaningful.

Another example of display intelligence is the DPO. Although limited in nature, it too has a memory for refreshing the display. It is limited to a fixed format of a single-valued function along the x-axis and two 40-character lines of alphanumerics for the top and bottom of the display. However, it also stores and thereby refreshes one complete frame for use as a standard (or signature) waveform. This is then displayed simultaneously with real-time waveforms to make comparisons. Other features

μV resolution is preserved with the precision of a programmable calculator in the Hewlett-Packard model 3050A Data Acquisition System. Adding a scanner to a multimeter and teaming them with a calculator, provides precision and control for scanning up to 100 data channels. On-line or off-line analysis of incoming data can be performed by programmed algebraic calculations.

include scaling the display in a linear or logarithmic manner and translating it prior to storage in memory. Again, intelligence provides a more meaningful display.

Interfacing with intelligence

A new area for incorporating intelligence is the instrument interface. Here, microcomputers or CPU's on a chip make increasingly complex (hence, extremely more intelligent) interfaces economically feasible. These augmented interfaces occupy less space and consume less power than equivalents built with combinational logic. With proper implementation, they are very adaptive and easily interface with different devices for a minimal change in hardware (cable) or microcomputer program (usually in a pROM).

The discussion so far has centered on using intelligence, now some of the ways of implementing intelligence will be discussed. Basically the implementation falls into two categories: special-purpose hard-wired logic and general-purpose programmable structures such as minicomputers and programmable calculators.

Special purpose logic. Intelligence may be implemented in special-purpose combinational logic. Advantages of this type of structure, since it may be the least hardware approach, are smaller size and weight, and faster operating speeds.

An example is any of the hard-wired FFT processors on the market (i.e. real time radar spectral analysis). They make decisions and follow instructions; hence, they are intelligent. They are about 1000 times faster than equivalent computer programs. Thus, they exemplify the speed characteristic of special-purpose logic but not the other characteristics, because they typically are larger and cost more than mini's.

GP programmable structures. Minicomputers, microcomputers and programmable calculators are examples of general-purpose programmable logic. The authors feel that they are the most feasible type of intelligence for use with instrumentation. Being programmable, they are adaptable to a wide range of uses and a wide variety of tasks, ranging from controlling to processing.

The minicomputer in the DPO exemplifies this flexibility for it controls the acquisition of waveforms, their formats, and displays as programmed in the BASIC language. It is this kind of flexibility that justifies the cost of a minicomputer.

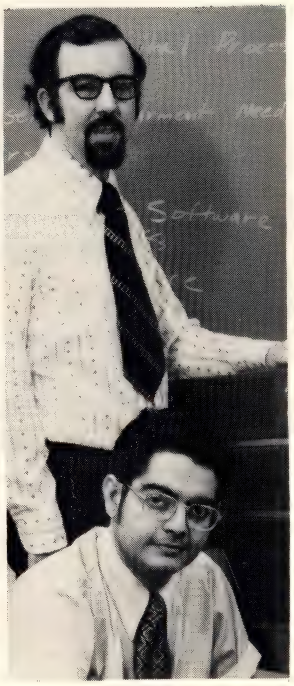
Easier to implement. Implementing intelligence with minicomputers is made easier than with special-purpose logic because of the availability of supportive techniques and equipment. Editor, assembler, compiler, debugging and test programs used in conjunction with a disc operating computer system (DOS) greatly simplifies software development for this implementation.

Software. Instrument intelligence implemented with a general-purpose programmable device is determined mainly by the programming or software. This software is as important as hardware, and, as such, should be developed concurrently with the hardware. In this manner, timely tradeoffs are made to minimize the cost of the instrument. Software should not be considered free simply because it is more difficult to price a word than a logic gate. At present prices, a word of software for a minicomputer costs about 60¢, while a logic gate is about one-third of that (less engineering costs).

Software is used to smooth over many of the rough spots in the man-machine interface. It can simplify the operation and controls, in addition to providing displays that are easier to understand. The software allows the user to control operation of the instrument via either pushbuttons or a terminal. Operation of the pushbuttons should be determined by the operator so as to fit his particular measurement requirements. In addition, he can write programs incorporating control and processing in a simple, interactive language such as BASIC.

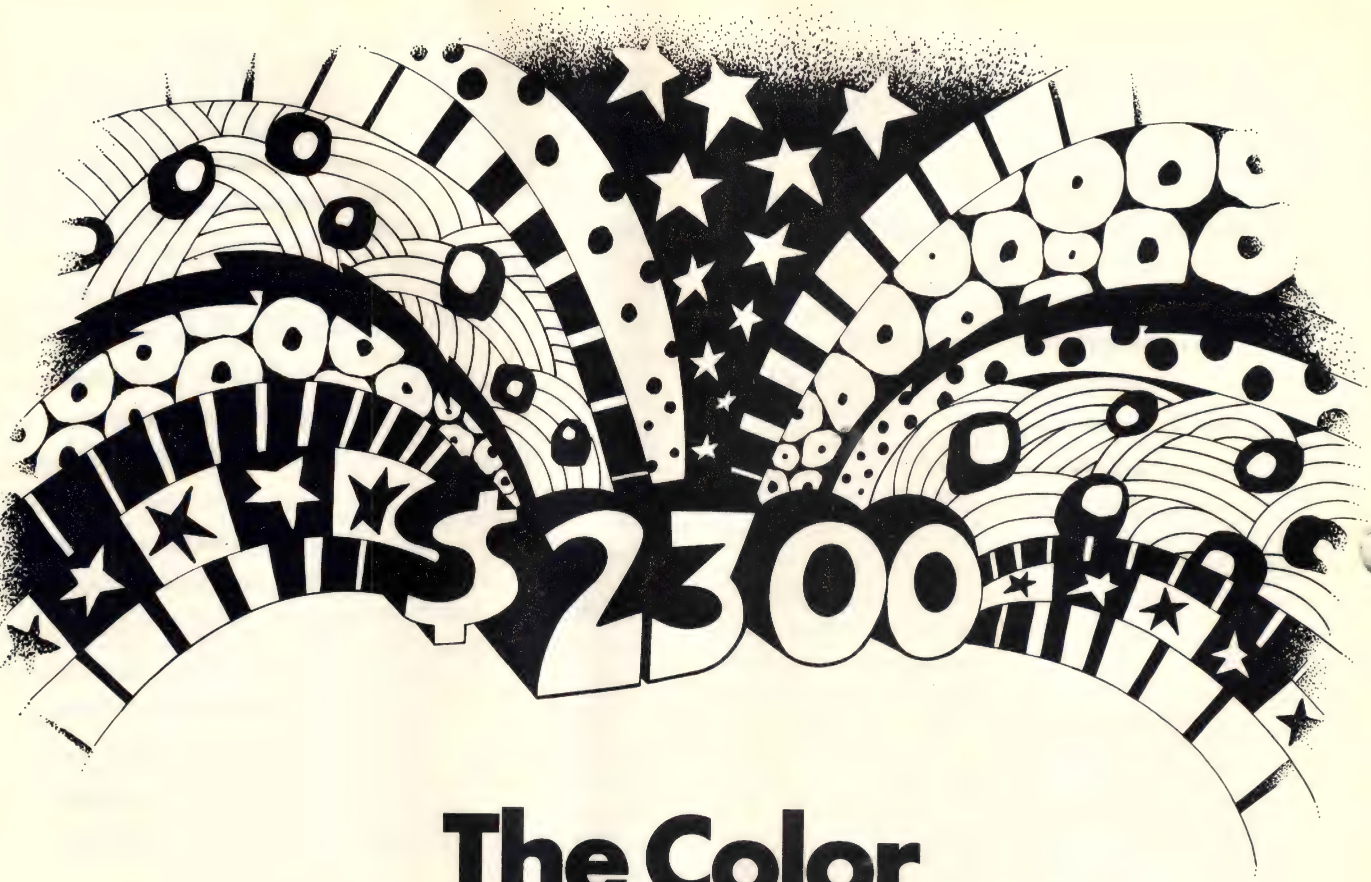
For example, the software could provide automatic features for picking the scale factors for a proper calibrated display. It could also perform a dimensional analysis during any processing in order to provide correct dimensional units with the scale factors. □

Authors' biographies



Bruce Hamilton, standing, is a software project manager for Tektronix. He obtained his BSEE from Oregon State Univ. in 1966 and his MSEE in 1968 from Ohio State. Besides his love for skiing and horses, Bruce has mastered the art of glassblowing.

Luis Navarro, seated, is a project leader in Tektronix' applications department, obtained his BSEE in 1965 and MSEE in 1966 from the Univ. of Nebraska. When his traveling permits it, Luis enjoys working on home improvements.



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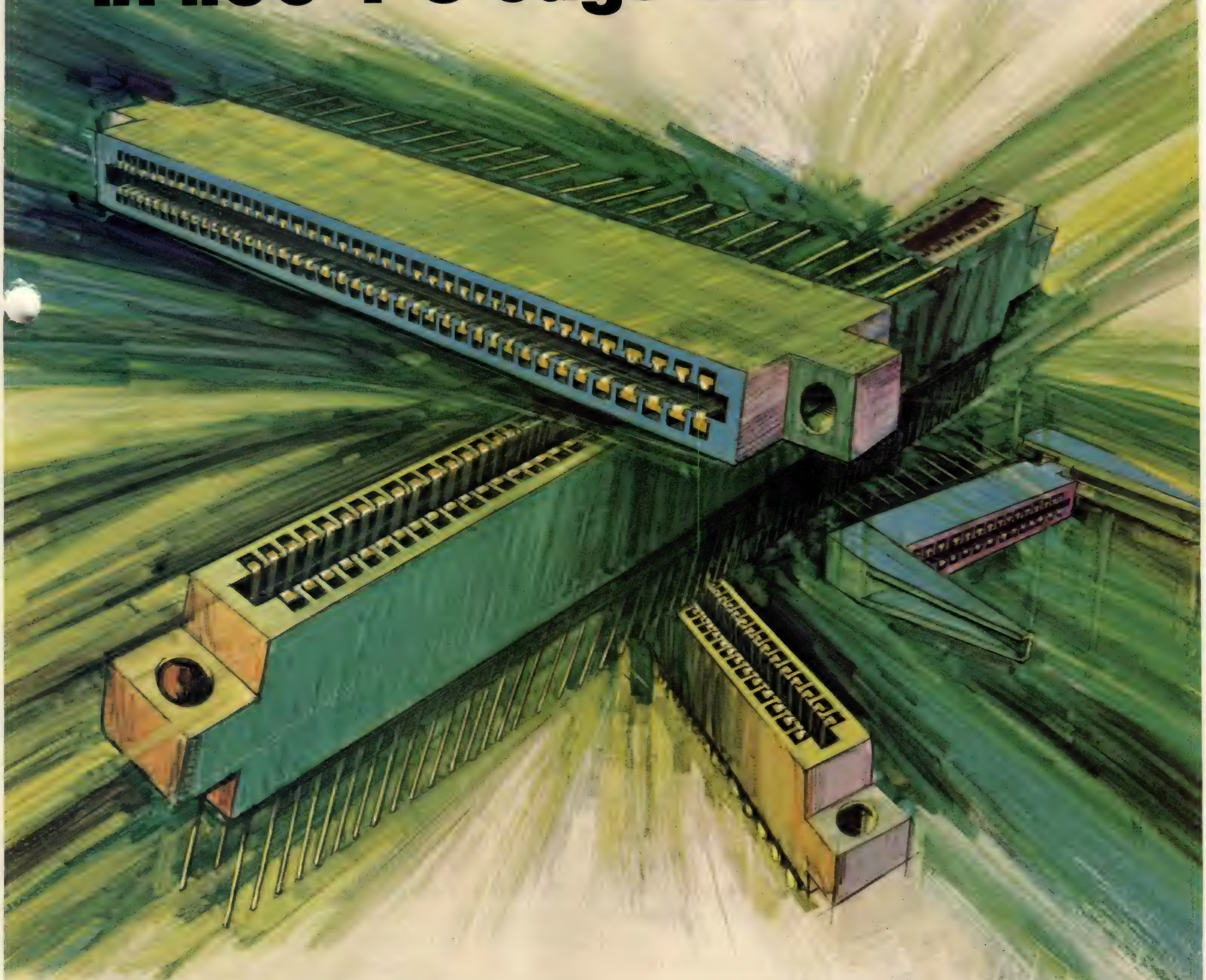

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How to get acquainted with a μP

Here's a down-to-earth approach for letting the microprocessor itself teach you what it's all about.

Robert H. Cushman, Special Features Editor

First steps are always the hardest. How does a designer who has never worked with a full general-purpose digital-computer (GP/DC) system get that initial familiarity with a specific in-the-flesh computer that opens up the doors to all GP/DC's?

The author faced this problem earlier in the year when Intel delivered a boxful of MCS-4 parts on his doorstep. This article is the solution to that problem. It should interest a wide group of EDN readers for it represents about the lowest level and lowest cost approach to getting familiar with microprocessors. The approach had to be low level because the author has the sort of "mechanical" mentality that demands a direct, nonabstract interaction with machines. ("You turn this knob and the music gets louder.") It had to be low cost because the author's budget was limited. These constraints eliminated the usual, more elegant aids such as teletypewriter input/output, spare pROM's ($60 each) and the equipment to program and erase them, debugging clip-ons, etc.

Instead, the author used a simple 16-line diode ROM to simulate the usual pROM and did his programming by plugging in diode arrays that represented the instruction codes (**Fig. 1**). We'll call this diode ROM simulator the EDN/DRS (to distinguish it from the Intel SIM4-01 simulator assembly that it was used with—**Fig. 1**). The Spartan simplicity of the author's approach has its good points. It gives almost anyone a working confidence that a machine like the MCS-4—which is not necessarily the easiest μP on the market to understand—can be understood and programmed to do useful things.

Circuit for EDN/DRS

The EDN diode ROM simulator (**Fig. 1**) is shown schematically in **Fig. 2**. It is partitioned into three plug-in levels that we will differentiate as EDN/DRS-1, EDN/DRS-2 and EDN/DRS-3.

The EDN/DRS-1 level plugs into the μP's pROM sockets. It picks up the lowest order four bits of the 8-bit address in the typical 256 line by 8-bits/line ROM's used in many of today's μP's. In the MCS-4 system this is the least significant 4-bit group in the 4004 CPU's program counter (PC) that the 4004 sends out at A_1 time slot in the master-machine cycle. It decodes these four bits with a CMOS Motorola 14514 4-to-16-line decoder. The outputs drive the 2N2222 transistors for the ROM lines directly, using the CMOS outputs as current sources. (The author has been warned by Fairchild application engineer Peter Alfke that this is not good practice, for one never knows if the CMOS devices have been spec'd for consistent drive characteristics; however, it does work.)

One advantage of this direct drive is that it is possible to insert either red LED's with 1.6V ON voltage or green LED's with 2.6V ON voltage as indicators in the lines. As will be seen later, these LED's are worth their weight in gold for they tell the user what is going on in the μP system.

With the series LED's it is a good idea to insert 1k resistors between the transistor base inputs and ground. These resistors will help insure that the transistors turn off rapidly and don't allow "ghost" ONE's from one line to show up in the next. Speed-up capacitors around the LED's may also help the simulator's output waveforms.

The EDN/DRS-2 level cards plug into the EDN/DRS-1 level board. These are the diode matrix itself, and they contain the sockets (AMP low-profile types) into which the level-3 diode arrays are inserted. The user can treat this simulator as two groups of eight lines since there are two arrays. This is handy when one wants to change a program midstream. He can leave the program cycling in a software loop in one half, while he pulls out the other half to insert other instructions. This makes it possible to correct programs in mid-execution or go onto programs longer than 16 lines.

The EDN/DRS-3 level is the actual diode arrays that code the machine. The author makes these up as instructions. He places the diodes in little

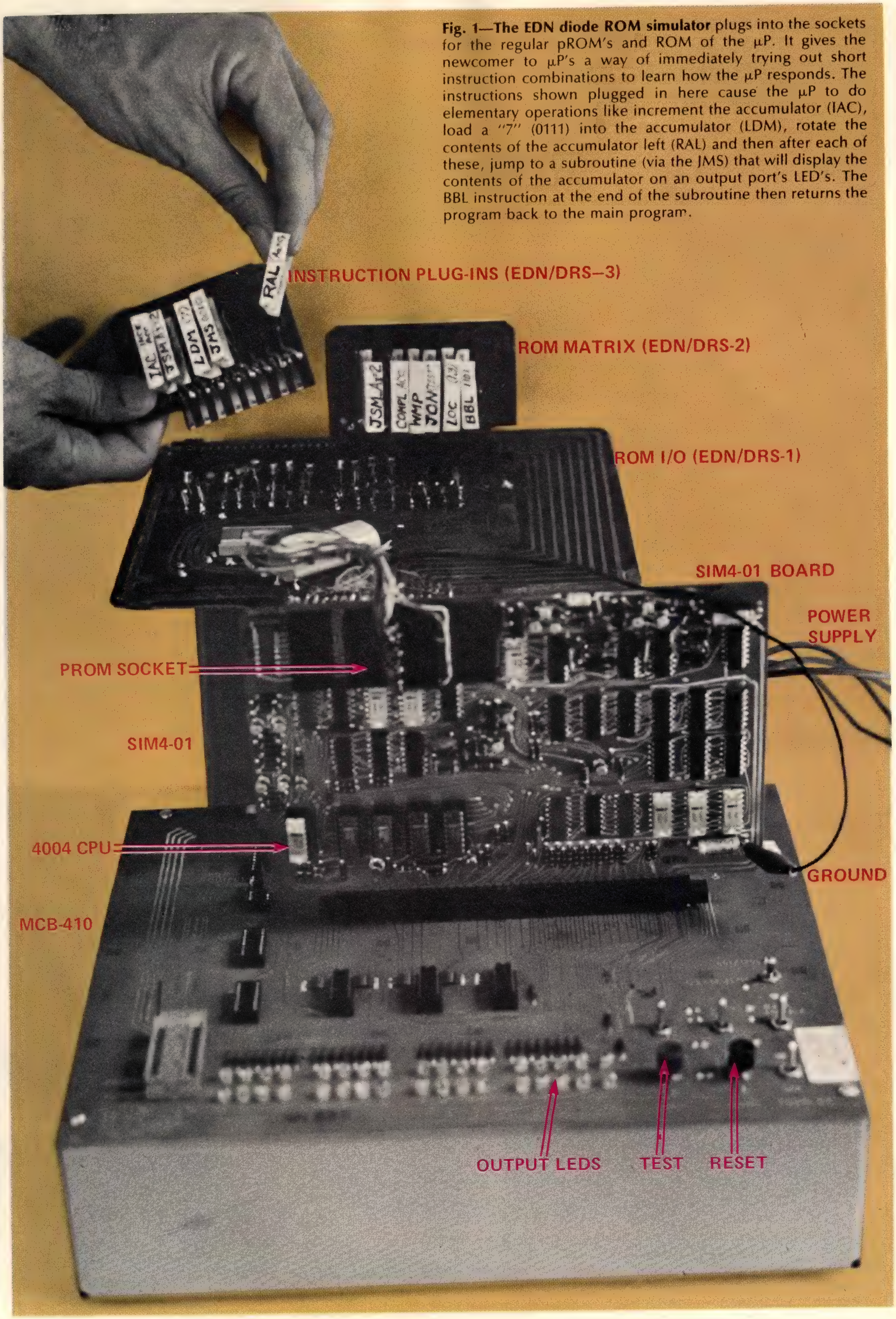


Fig. 1—The EDN diode ROM simulator plugs into the sockets for the regular pROM's and ROM of the μP. It gives the newcomer to μP's a way of immediately trying out short instruction combinations to learn how the μP responds. The instructions shown plugged in here cause the μP to do elementary operations like increment the accumulator (IAC), load a "7" (0111) into the accumulator (LDM), rotate the contents of the accumulator left (RAL) and then after each of these, jump to a subroutine (via the JMS) that will display the contents of the accumulator on an output port's LED's. The BBL instruction at the end of the subroutine then returns the program back to the main program.

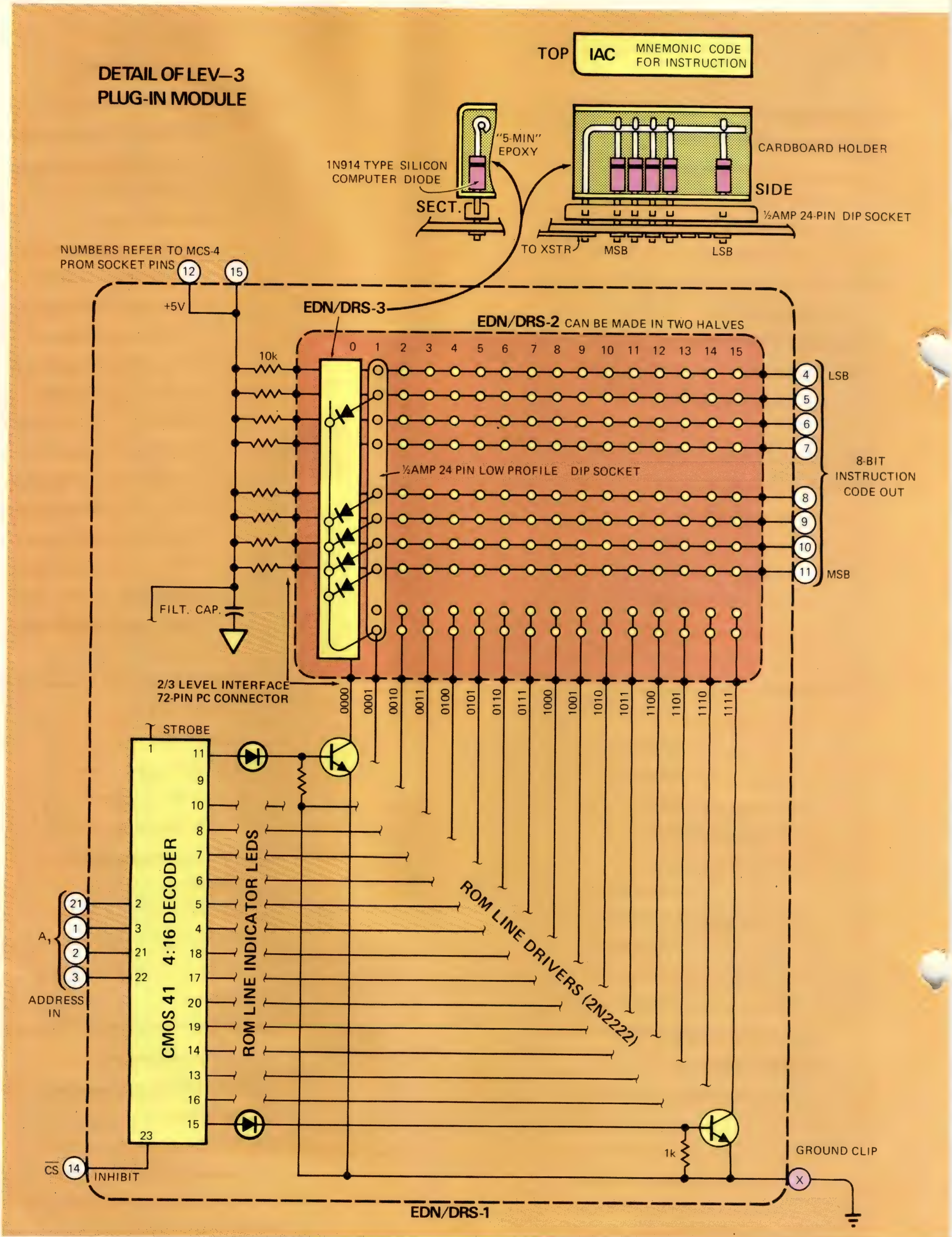
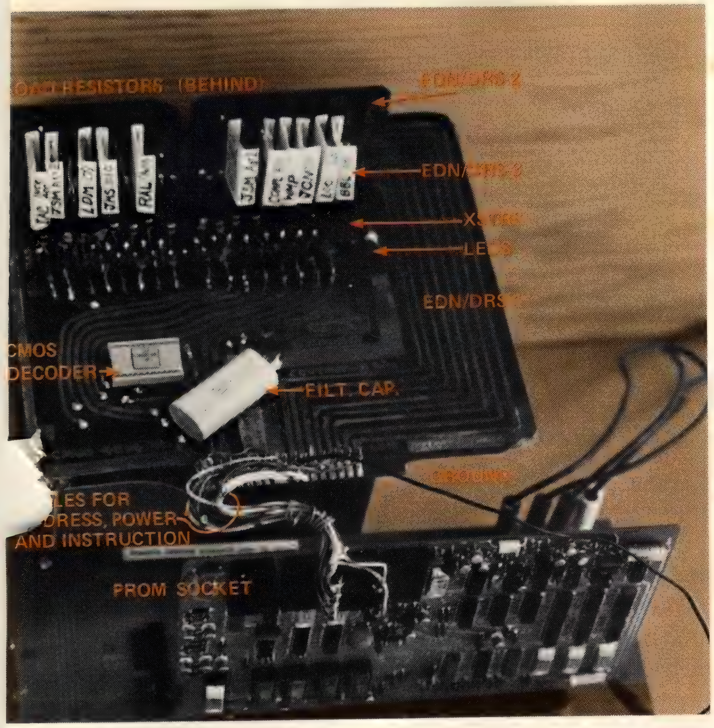


Fig. 2—The EDN/DRS circuit. Just four of the eight address inputs for the regular pROM are used. However, all eight bits of the instruction code are delivered. A CMOS 4:16 decoder provides the address decoding, and 2N2222 transistors drive the diode matrix lines. The diode arrays plug into the matrix lines and "pull down" those output lines that are to be ONE's. The circuit is partitioned into three levels, which are labelled EDN/DRS-1, -2, -3.



cardboard holders so they implement the ONE's for the instruction (empty positions automatically represent ZERO's) and solders their top leads to a common wire that leads to the collector of the line-driving transistors. Then he epoxies the assembly to make it a rugged plug-in module. Last, but really most important of all, he labels the top of the little modules with the mnemonic for the particular instruction it codes.

A simple act of writing the mnemonics on the plug-ins (like IAC on the module in **Fig. 2**) effects a Cinderella-like transformation of the modules. No longer do you think of them as hardware circuits of diodes, or even firmware machine-language codes. The label transforms them in your mind into assembly-level software. You think of them as your written commands to the tiny 4004 CPU, telling it what you want it to do. To insure that your EDN/DRS-3 modules keep providing this nudge to convert you to software thinking, put your mnemonic labels in big, bold letters on the top fold-overs of the paper carriers. Then they will still be visible when plugged into the EDN/DRS-2 sockets.

The diode array for the MCS-4's IAC or increment accumulator instruction plugs into the second ROM line in **Fig. 2** (address 0001). The first line (address 0000) has no diodes plugged in. It presents a 0000 0000 code to the MCS-4 that the 4004 CPU interprets as a NOP or "no operation" instruction. This is a handy feature of the MCS-4's instruction code from the standpoint of the EDN/DRS. It doesn't hurt to leave lines empty, as the 4004 will just step past them without doing anything. You'll find some other code combinations that the 4004 will ignore as you work with this simulator.

At first it was thought that Schottky diodes would be needed to guarantee low ZERO-level outputs from the EDN/DRS to insure proper interfacing with the following TTL 8234 multiplexer on the Intel SIM4-01 side of the system. HP 5082-2833 Schottky's were used and they did provide excellent low ZERO levels for positive pull-down of the TTL inputs. But subsequently, it was found that practically any type of silicon "computer" diode was adequate. As it easily takes hundreds of diodes to make up the minimum of several sets of modules needed for the MCS-4's 45 instructions, one appreciates the economy of buying diodes in packs of 50 at 3¢ apiece vs. Schottky diodes at about $1 each.

The output signals of the ROM matrix are developed across the 10k resistors on the EDN/DRS-1 board and sent back to the appropriate pins on the Intel 24-pin pROM socket. From there they are routed via the TTL multiplexer just mentioned to the 4004 CPU chip to complete the instruction-fetch cycle (time slots M_1 and M_2 in the MCS-4 μP system).

Some practical hardware matters

To fully understand the Intel side of the system you need to study their circuit for the SIM4-01, as shown on pgs. 62-67 of the "MCS-4 Users Manual" (**Ref. 3**). The EDN/DRS-1 can be plugged into any of the 24-pin pROM sockets of the Intel SIM4 development systems. The reader should be alerted that Intel has replaced the SIM4-01 system with newer prototyping board assemblies that use a pair of LSI/MOS circuits—the 4008 and 4009—to replace much of the TTL on the SIM4-01.

According to Larry Goss at Intel who handles customer applications on the MCS-4, the nearest thing to the SIM4-01 that Intel now makes is the IMM4-42 board used in the Intellect-4 microcomputer console. (Of course if you can talk your management into spending $2500 plus and buying the full Intellect-4 microcomputer and its accessories, you should not be wasting your time reading this article.) The IMM4-42 board is still fairly expensive, selling for $395 in singles.

If you really do have a budget problem, you should consider getting ahold of the 4004 CPU that costs $60 in single quantities. Then, build your own minimum system around it to interface to something like the EDN/DRS, using TTL or CMOS. You should begin with the SIM4-01 circuit diagram and scratch out all the nonessentials. As a starter, scratch out the 4002 RAM's as the 4004 CPU has enough on-board registers to illustrate the execution of most of the instructions. Also, you can dispense with all the I/O except for one output port that is needed to display the contents of the accumulator. Introduce the data needed to exercise the instructions via the EDN/DRS, as we will describe. Only one pROM socket is necessary for the EDN/DRS. Since you will be using only the lowest four bits of the program address from the 4004's 12-bit PC, you will probably find you can greatly simplify the decoding and routing circuits for the pROM. You will, of course, need the clocks. **Ref. 5** shows a CMOS clock for the MCS-4 that seems simpler than Intel's multiple one-shots.

The author estimates that such a "naked-µP" version of the MCS-4 built for introductory training purposes could be built for about $100 parts cost. Admittedly, it would entail a certain amount of design and construction time and effort on your part. But if you planned to be a serious user of the MCS-4 in minimal systems, the educational value of the project could prove valuable. It would expose you to the art of attaining a balance between the universal flexibility of an "all-up" GP/DC system and the minimum hardware cost of a stripped-down (but adequate for the task) GP/DC system.

By the time this article appears, Intel may have introduced the low-cost parts kits for its computers that has been in the planning stage for many months now. In the case of the MCS-4, the kit would consist of six MOS/LSI parts, one each of the 4004 CPU, the 4008 and 4009 interfaces, a 4002 RAM, a 4702A pROM, and the 4003 I/O shift register serializer. It would be sold off distributor shelves for $99. The kit includes a representative circuit diagram to show purchasers how to put the parts together in a working system. Initially, the EDN/DRS could be substituted for the 4702A pROM in this system.

Don't let the current high prices for these µP's discourage you. Someday we predict—and many in the industry agree—a part like the MCS-4 4004 CPU will sell for $5. So get started now; if you wait until the 4004 is selling for $5, it may be too late. You can't learn how to creatively use these machines overnight.

What can you do with 16 lines?

It will be assumed that you are working with a SIM4-01 board and that it has been plugged into an MCB-410 box that carries the RESET and TEST buttons and the I/O ports, with the output ports having LED indicators. It will also be assumed that you have supplied the MCB-410 with the required +5 and −10V power supplies.

The EDN/DRS is plugged into the second pROM socket (**Fig. 1**), the other three sockets being empty. You clip its ground lead to some convenient spot on the SIM4-01 board, as the pROM socket has no pin carrying ground.

PROGRAM ADDRESS (A_1)		INSTRUCTION SEQUENCE (PROGRAM)		
ROM LINE	LED	MNEMONIC	GENERALIZED CODE	ACTUAL CODE
0 (0000)	OFF	— — — — —	— — —blank	0000 0000
1 (0001)	OFF	IAC	1111 0010	1111 0010
2 (0010)	OFF	SRC	0010 RRR1	0010 0001
3 (0011)	OFF	WMP	1110 0001	1110 0001
4 (0100)	LIT	JCN	0001 CCCC	0001 0001
5 (0101	LIT	(line address)	A_2 A_1	0000 0100

Fig. 3—This is the sort of simple program you will want to employ at the outset to familiarize yourself with the µP's instructions, one by one. Here you are investigating what happens with the IAC or increment-the-accumulator instruction. You plug the diode array for this instruction into line 1, and then you use the remaining four instructions to display what happens on the LED indicators at an output port.

When you first turn on the power supplies (in any order), the only indication of system operation is a dim glow on all the LED's in the ROM drive lines. They will be dim because they are being driven at 1/16th duty cycle (if you've wired in the pROM "chip enable" to the CMOS 4:16 decoder, they will be even dimmer because then the socket is activated only 1/16th the time). At this time push the RESET button. This will supply (via a one-shot) a pulse long enough to clear all the 4004 registers (**Ref. 3, pg. 10**). The MCS-4 does not have an automatic reset upon power up.

The first thing you will want to do is introduce some data into the 4004 accumulator and then read it out to prove to yourself that it was actually introduced. It never hurts to crawl a bit before you walk and run. The classical way to introduce data into the computer is via the input ports. You can do that, but at this primitive stage of things, a much more direct way to introduce data is via code in the EDN/DRS.

There are a surprising number of MCS-4 instructions that will inject data into the 4004 CPU: LDM, FIM, IAC, DAC and even BBL. A good one to use is IAC which increments the accumulator. It was shown plugged into ROM line 1 in **Fig. 2**. An advantage of IAC is that it will cause a change each time its ROM line is addressed. Therefore, you have a way of knowing if it is being fetched and executed by the 4004 CPU.

However, just plugging the IAC code into the EDN/DRS will be meaningless. It may have caused the 4004's accumulator to increment—it may not. There is no way for you to know. You have to make the 4004 read its accumulator contents out on one of the output ports so you can look at it. The instructions to do that are shown following the IAC in **Fig. 3**.

In each case the ONE's in the code represent where diodes should be placed. The SRC commands the 4004 CPU to tell the outside world which port it wants to address. The RRR bits of the generalized SRC code select a pair of 4004 registers and send their contents out. To save diodes it's expedient to let RRR be 000. This sends out the "0" pair. As you have just applied the RESET you can assume the contents of the "0" pair will be 0000 0000, so a "0" port will be addressed. Actually, SRC is used to set up addresses for both external RAM memory and I/O ports. It won't be until the specific data-movement command is fetched that the system will know to what use to put the information sent out by the SRC.

The WMP instruction plugged into ROM line 3 provides the specific command. It tells the 4004 to copy out the contents of the accumulator on the data bus and also sends out the strobe pulse that latches the data into the previously-addressed (by SRC) RAM port. Confusing, isn't it? But the beauty of the little "mechanical" EDN/DRS is that you've reduced the abstractions of the MCS-4 manual into little jigsaw pieces you can hold in your fingers. You can put them together this way and that until the way the system plays and the way you think it should play come into agreement.

"Stopping" the clock

With the completion of the WMP instruction, the 001 in the accumulator also will be displayed on the LED's of RAM output port "0." But you won't see it. Instead, you'll just see a dim blur on all the port "0" LED's. The MCS-4 is a dynamic system that runs continuously, and its 12-bit PC counter just keeps counting and loops around back to the starting address of the EDN/DRS (line 0000) and on to one IAC after the other. Though the MCS-4 is not a particularly fast μP, it still only takes 10.8 μsec/machine cycle (ROM line). Thus, even if it had to go through all 4096 machine cycles on every loop, it could do so at a rate of 44 msec that would not produce a visible flicker on the readout LED's.

To stop this endless cycling through IAC's, you plug in the JCN instruction in ROM lines 4 and 5 (**Fig. 3**). This JCN is one of the MCS-4's two decision instructions. The least significant four bits in its first line sets up tests for the 4004 CPU to make. The second line tells the 4004 where to direct its PC to fetch the next instruction. The ONE bit in the least significant bit of the first line tells the 4004 to check the TEST line. If the TEST button has not been pushed, the address for the next instruction-fetch from the ROM is to be that given on the second line of the JCN, or 0100. This will loop the program back to the first line of the JCN, effectively stopping the dynamic MCS-4 from going on to following ROM lines.

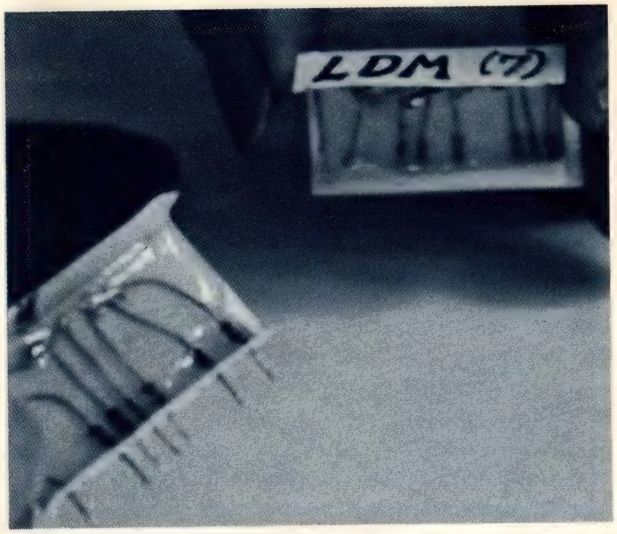


Fig. 4—Your conversion to software comes when you think of the EDN/DRS-3 instruction plug-ins not in terms of their diode arrays (hardware), but in terms of their mnemonic labels (software).

With the EDN/DRS it is very easy to see this JCN loop, for the LED's at lines 4 and 5 will be glowing brightly. We've seen no computer display console, big or small, that does such a straightforward job of telling a human observer where the machine is at. You should use a loose diode for the second line of the JCN so you can poke it in and out of several of the holes and watch the loop expand and contract accordingly—that's the sort of instantaneous learning feedback that makes the operation of a μP "come alive." It doesn't hurt the MCS-4 to change diodes while the machine is operating.

Now suppose you push the TEST button; what happens? The output port will instantly change to the next count or 0010. Obviously, you've released the MCS-4 from the JCN loop, and it runs back around through another IAC and is stopped by the JCN again. The two LED's at lines 4 and 5 won't even flicker as the run will take just 14 machine cycles.

Fourteen pushes of the test button will produce 1111 in the accumulator, and the fifteenth push of the TEST button will produce 0000. At this point there will be a ONE in the 4004's carry FF, but you won't be able to see that with this simple readout. You'd have to insert a RAR for a right shift before the WMP to see that.

What else can be done with this most elementary little 5-line routine? The JCN is able to command the 4004 to make multiple tests simultaneously. If its CCCC code is 0101, it will have the 4004 not only check the TEST line, but check whether the accumulator content is ZERO. When the first line of the JCN is 0001 0101, the system will start off behaving as before. The readout at port "0" will initially be 0001, and it will count up by ONE each time you push TEST. But when the readout shows the accumulator has gone to 0000 at the fifteenth push of TEST, you will find that from then on the TEST button will not be able to release the JCN loop. The additional condition, "jump if accumulator content zero," overrides the release of the TEST condition.

Plan a study program for yourself

With an EDN/DRS-type setup, you'll find you can embark on a painless little self-study program on whatever μP you elect to become familiar with. The author foresees no obstacles in applying the EDN/DRS to other μP's beyond such minor modifications as changing the ROM socket pinouts and possibly slowing down the clock. The instantaneous plug-in programmability of an EDN/DRS-type setup makes it an ideal self-teaching aid for the weary engineer at the end of the day.

Ideally, you should have such a setup in your own home, where you can go to it "asynchronously," and spend as little or as long a time in each session as you can. The author has found that useful results can be obtained in sessions as short as five minutes, but typically you become so engrossed in your "conversation" with your little teacher that hours fly past before you know it.

The curriculum you outline for yourself ought to be based on three progressive levels of study. First, you should work your way through the μP's instruction set, instruction by instruction. For each instruction you first should devise simple routines (as we did for the IAC in **Fig. 3**). Then, devise more complex variations of those routines to answer all the questions that will come to mind about what the μP does as it executes that command. Keep a notebook as you go, describing in detail the μP's behavior for each code combination, and listing any questions that are left unanswered. (*If the μP supplier can't answer your questions, send them to EDN. We are planning a "μP Clinic" column that will be devoted to tracking down answers to knotty μP application problems.*)

Second, after becoming reasonably familiar with the μP's instruction set, try your hand at writing basic subroutines. Make a habit of collecting subroutines you find in the literature and filing them in some organized fashion. This will be the start of your software library. See if you can't implement them on the EDN/DRS. The author has found that the jist of most subroutines—BCD counting, time delays, analog-to-digital conversion in conjunction with external ladders and comparators, list searches, etc.— can be squeezed into the 16 lines, one way or another.

Third, learn how to assemble your subroutines into useful complete application programs. Now, you'll feel the pinch of EDN/DRS's 16-line limit. Yet, you can put in two brief subroutines on the second half card of the EDN/DRS-2 level and then put the JMS jump to subroutine commands on the first half. So what if your subroutine housekeeping commands take up more lines than your actual application instructions; you are using this to learn. Besides, the very limitation of 16 lines will give a discipline to your self-education that will make you a more efficient programmer in the future.

As you progress up this 3-step ladder, you can't help but absorb the "psychology" of software hierarchies. The EDN/DRS can help you here too. Suppose you find that you keep using a certain set of instructions over and over again. You decide to hardwire the diodes for that into one of the EDN/DRS-2 level cards. Then it strikes you that it would be handy to put a "macro" mnemonic label on it, thus you invent a term. You might wire up the accumulator readout of **Fig. 3** and call it ACCOUT, or you might wire up a 1-msec time delay and call it MILSEC.

From then on, whenever you need one of these functions, you won't stop to re-create it line by line, but will simply reach over to your "software parts" drawer and pull out an ACCOUT or MILSEC. It then becomes self-evident why there is such intense interest in higher-level software.

The door that something like the EDN/DRS can start opening for you leads to a very big universe indeed. Similar to those cartoons, where a door at the end of a room opens to celestial space, no one knows where it ends.□

Ed note:
Readers interested in the particular EDN/DRS described here can write to the author, care of EDN, for a rough copy of the PC board layouts and construction hints on the plug-in modules.

References

1. *"Don't overlook the 4-bit μP: they're here and they're cheap," EDN, Feb. 20, 1974, pg. 44.*
2. *"What can you do with a microprocessor?" EDN, Mar. 20, 1974, pg. 42.*
3. *"MCS-4 Micro Computer Users Manual," Rev. 4, Feb., 1973, Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. (The latest MCS-4 manual, Rev. 4, Mar., 1974, does not contain the detailed schematic for the SIM4-01, showing how TTL can be used for the interfacing.)*
4. *"The Designers Guide to Programmed Logic (For MCS-4 Systems)," by Matt Biewer, Pro-Log Corp., 852 Airport Rd., Monterey, CA 93940.*
5. *"Supplemental Information to the MCS-4 Users Manual," Frederick Buuck. (Write to EDN for author's address.)*

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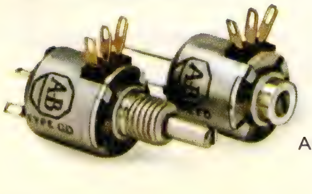
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Circle No. 33

Quad linear contest winners show high degrees of creativity

EDN and National Semiconductor had great difficulty judging winning entries. All were top caliber. Here are the best of the best.

Art Fury, National Semiconductor Corp. and **Walt Patstone**, Managing Editor

Purpose of the National Semiconductor/EDN quad linear contest was to stimulate creative thought in a new channel. We wanted to demonstrate that a quad linear device was not just four op amps or four comparators in a single package, but a completely new "function." As such, it should open up many new applications that would be entirely impractical if only individual devices were available.

Response to this challenge was extremely gratifying. Our goals were exceeded beyond our highest expectations. We greatly appreciate the efforts of all who entered.

Everybody wins when four linear devices are packaged in a single 14-pin DIP. Cost and space savings make feasible a myriad of new applications.

The complete list of winners

Place	Prizes	Winner	Company	Design
1	Panasonic 4-channel Entertainment System	M.G. Strange	Goddard Space Ctr., Greenbelt, MD	Staircase Calibrator
2	Zenith Portable Color TV's	W.J. Renison, Jr.	Sanders Associates, Inc. Nashua, NH	TTL Logic Pen
3		V.R. Godbole	North Electric, Galion, OH	Video Sync Processor
4		R. Tenny	Texas Instruments, Dallas, TX	Programmable Power Supply
5		F.W. Colver	Seymour Instruments, Orange, CA	Rotory Pulse Encoder
6	Garret "Incredible Time Machine" Clock/Calculators	B. Krlig	Wauwatosa, WI	Heart Rate Warning Device
7		L.A. Stovall	Caldera Enterprise, Los Alamos, NM	Waveform Generator for dc Motor Control
8		L.M. Richey	Matric, Franklin, PA	Low Power Battery Operated Keyer
9		J.T. Heizer	Narco Avionics, Ft. Washington, PA	N-Bit, Self-Correcting A/D Converter
10		A.E. Ripingill, Jr	Cubic Industrial Corp., San Diego, CA	Frequency/Phase Meter

Judging was a pleasant and exciting task, but one made extremely difficult by the variety, quality and originality of the entries. NSC application engineers performed the yeoman work of narrowing the field considerably and testing all circuits qualifying as finalists. EDN editors then carefully considered each qualified design and determined the official outcome. The race was indeed a close one.

So—What can you do with a quad linear IC? For your inspiration, we are pleased to present the top five circuit designs. If they stimulate your thoughts, then we are all winners.□

Staircase calibrator features excellent stability

Maxwell G. Strange

This unique circuit (**Fig. 1**) generates a single, very accurate staircase sequence every time it is triggered. The number of steps, step height, and stepping rate are easily set up. One application is for amplitude calibration of FM tape recorders or telemetry systems. High stability (±0.2% from 0 to 50°C) is achieved with a circuit arrangement in which the drift characteristics of two similar

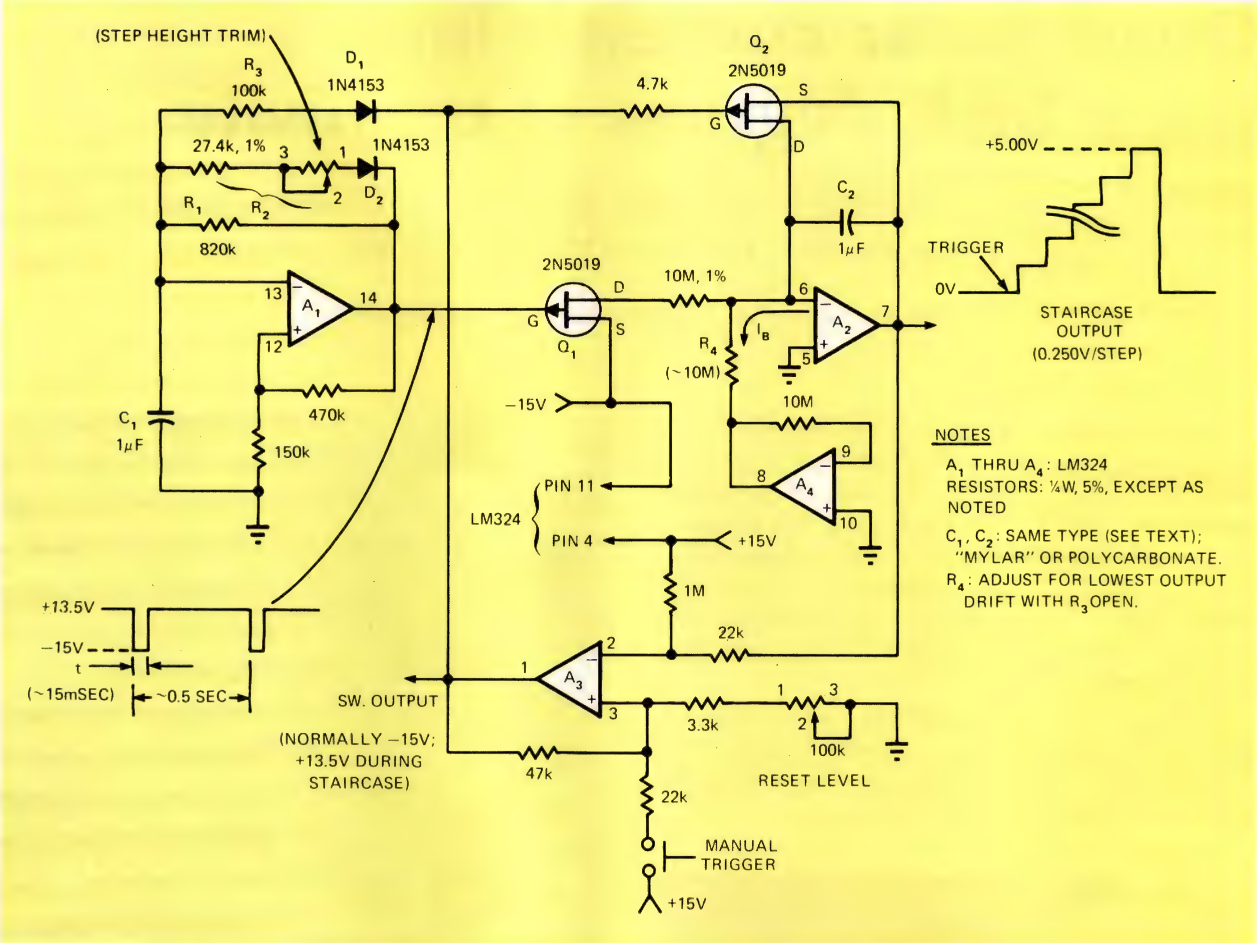


Fig. 1—As long as ratio of C_1 to C_2 is maintained, step heights remain constant. Excellent matching of bias currents allows A_4 to effectively sink input current of A_2, so even long staircase steps remain level. Circuit stability is ±0.2% over 0 to 50°C.

capacitors cancel. The calibrator, once triggered by either a pushbutton or a logic pulse, generates 250 mV steps from 0 to +5V (21 levels) with a dwell time of about 0.5 sec, as shown by the recording (**Fig. 2**).

The 4 sections of an LM324 quad op amp are used as pulse generator, integrator, comparator/bistable switch, and bias compensator. In the circuit's "resting" state, the staircase output is at ground and comparator/switch A_3's output is at −15V. In this state, A_3 inhibits pulse generator A_1 via the path through diode D_1. It also holds FET Q_2 ON, keeping the output of operational integrator A_2 at ground. When a trigger pulse is applied, A_3's output switches positive, activating pulse generator A_1 and turning Q_2 OFF.

Take it a step at a time

Staircase generation proceeds as follows. Whenever a negative-going pulse from A_1 is applied to the gate of FET Q_1, C_2 is charged by an amount:

$$\Delta V_C = \frac{15t}{R_3C_2}$$

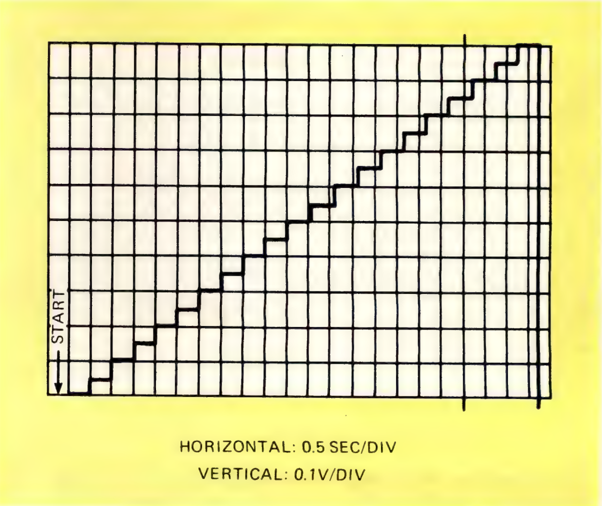


Fig. 2—0 to +5V staircase contains 21 levels in 250 mV increments. Apparent slight deviations are due to strip-chart recorder nonlinearity.

This creates an output voltage step. Between steps, A_2 holds the charge on C_2, and thus the output level, constant. When the staircase amplitude exceeds a voltage threshold determined by

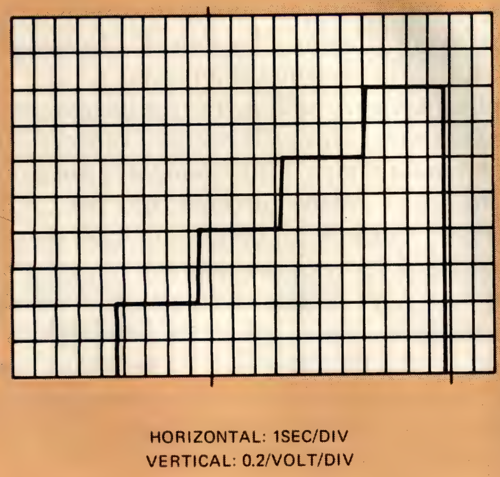


Fig. 3—Increasing C_1 to 8 μF produced this 0 to +8V staircase containing 5 levels in increments of 2V. RESET LEVEL POT was set for just over 8V, while STEP HEIGHT TRIM was adjusted for exactly 2V.

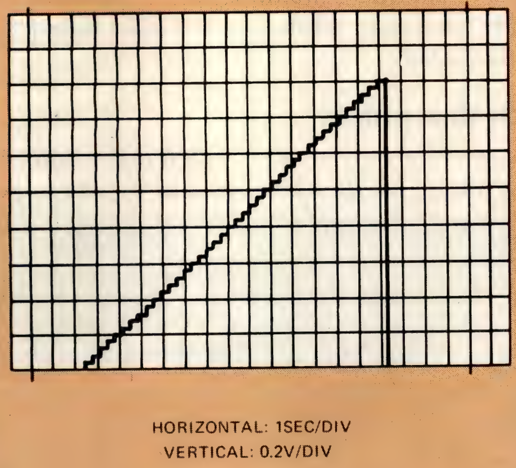


Fig. 4—To get this 41-level staircase, C_1 was changed to 0.8 μF.

the "reset level" trimpot, A_3's output switches negative, returning the circuit to its stable resting state. The circuit cannot latch in an inoperative mode.

The unique feature largely responsible for this circuit's excellent stability is the fact that step heights are not affected as long as the ratio of C_1 to C_2 is maintained. If C_1 increases, pulse width increases proportionally, increasing C_2's charging time. However, if C_2 increases by the same percentage, the charging slope is reduced, leaving step height unaffected. Thus, if the temperature coefficients and aging characteristics of C_1 and C_2 are the same, no error will result from capacitor drift.

Although dual supplies are needed, the special features of the LM324 are used to advantage. Since the outputs go virtually to $-V_{CC}$, Q_1's gate can be coupled directly to A_1. The excellent input bias current matching between amplifiers in a given quad enables the fourth amplifier to effectively sink the input current of the integrator. This keeps integrator drift very low in its "hold" mode. As a result, long staircase steps remain level. If R_4 is trimmed for exact bias cancellation, a drift of only a few millivolts per minute can be achieved.

Go up either the ramp or the stairs

Duty cycle of the pulse generator is approximately R_2/R_3. On-off control is arranged so that a "zero" level is always included at the beginning of the staircase. The "switch output" is often useful in a system connection to switch the staircase onto a data line. A_1 and A_3 could be fast comparators, but op amps perform equally well here since fast switching is not required. Sensitivity of step level to power supply voltage is about 3%/volt for the positive supply and much less for the negative supply. For best long-term stability,

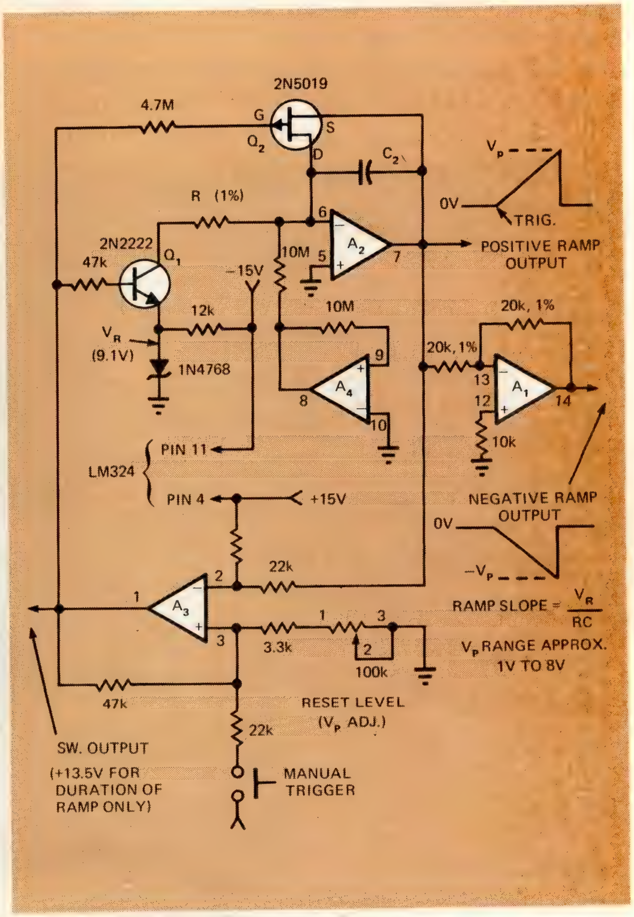


Fig. 5—Need a single ramp? Circuit of **Fig. 1** is easily converted. In the process, op amp A_4 becomes available to provide a complementary output.

power supplies should be regulated and low-drift resistors used where 1% units are specified.

Figs. 3 and **4** indicate circuit flexibility. These outputs were obtained by merely changing the value of C_1 and resetting the trimpots.

Application possibilities for this design are not limited to staircases. Calibration sources often need accurate ramps. One example is the generation of very small currents by the "ramp-capacitor" method to check electrometer amplifiers. **Fig. 5** shows a rearrangement of the basic circuit which generates a single, precise ramp when triggered. Since the pulse generator is not needed in this modification, A_1 becomes free to serve as an output inverter. Thus complementary ramps can be made available. Slope sensitivity to supply voltage is only 0.3%/V. □

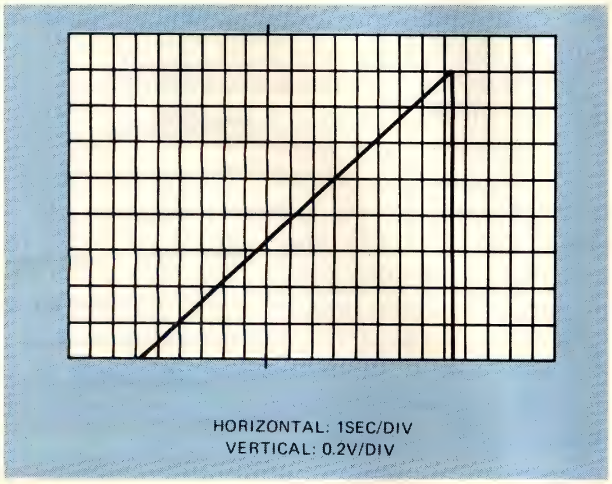


Fig. 6—With R = 5 MΩ, C = 3 µF, the output of the ramp generator of **Fig. 5** looks like this.

Logic pen is small, but effective

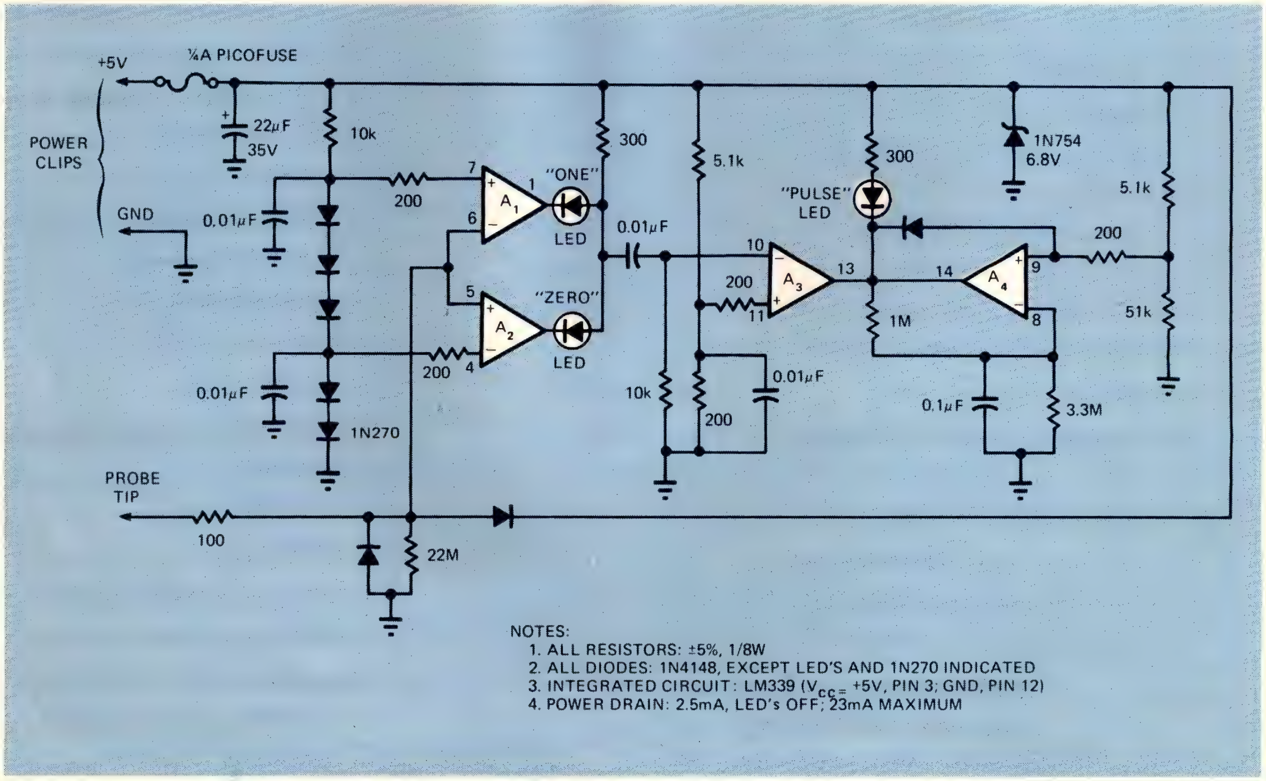
William J. Renison, Jr.

This TTL logic pen (**Fig. 1**) uses a single LM339 quad comparator, performing multiple functions, as its only active component. It features a high input impedance and can detect single pulses greater than 100 nsec wide.

A diode chain generates reference voltages for A_1 and A_2, the ONE and ZERO level detectors. Indicator LED's tied to the outputs of these comparators are driven at approximately 10 mA, providing adequate illumination. A common load resistor prevents both LED's from being ON simultaneously.

Catch that pulse!

Comparator A_3 is an ac-coupled pulse amplifier whose input is OR'd from A_1 and A_2. Whenever



NOTES:
1. ALL RESISTORS: ±5%, 1/8W
2. ALL DIODES: 1N4148, EXCEPT LED'S AND 1N270 INDICATED
3. INTEGRATED CIRCUIT: LM339 (V_{CC} = +5V, PIN 3; GND, PIN 12)
4. POWER DRAIN: 2.5mA, LED's OFF; 23mA MAXIMUM

Fig. 1—Pulses >100 nsec wide are caught by this circuit and displayed by the "PULSE" LED for approximately 0.3 sec. A_1 and A_2 are used as level detectors/LED drivers; A_3, as a pulse amplifier; and A_4, as a one-shot.

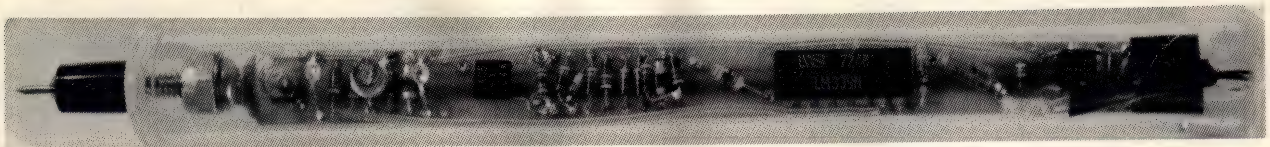


Fig. 2—Built inside a 1/2-in. ID Plexiglas tube, the logic pen was covered with black heat-shrink tubing (except around LED's) after this photo was taken. To improve performance, use low capacitance protection diodes and add a ground clip on pen body.

the logic level changes, A_3 illuminates the "pulse" LED. More importantly, however, A_3 simultaneously drives the noninverting input of A_4 negative. Thus, A_4 becomes a 1-shot multivibrator, maintaining the illumination of the "pulse" LED for approximately 0.3 sec. The exact ON time period is determined by the time constant of the RC network connected between A_4's output and its inverting input.

The prototype logic pen was built in a 1/2-in. ID Plexiglas tube (**Fig. 2**). After the photograph was taken, the tube was covered with black heat-shrink sleeving, leaving only the indicator LED's exposed.

Simple improvements should make this circuit capable of catching pulses even more narrow than 100 nsec. In particular, the input protective diodes could be replaced by low-capacitance types and a ground reference clip added to the pen body.□

Single quad comparator yields complete video sync processor

V. R. Godbole

The ability of an LM339 quad comparator to operate from a single power supply plus its medium speed capability are used to advantage in this video sync processing circuit. Purpose of the circuit is to separate the composite sync information from the composite video signal, then to further separate the composite sync signal into its horizontal (15.75-kHz rate) and vertical (60-Hz rate) components. These components are used to phase lock the horizontal and vertical oscillators in the video system.

Fig. 1 shows the system block diagram; **Fig. 2**, the schematic; and **Fig. 3**, pertinent waveforms.

Slicing the video

Referring to **Fig. 2**, observe that transistor Q_1 inverts and amplifies the input video signal. Q_2, an emitter-follower stage, feeds diode D_1 that clamps the inverted video to one diode drop above ground. Voltage divider R_9 and R_{10}, in conjunction with diode D_2, bias the negative input terminal of comparator A_1 at about one-half diode drop above ground. Therefore, in the absence of a video signal, A_1's output is HIGH.

During video portion of the signal, A_1 normally switches LOW, except during the sync period. The sync pulse causes the noninverting (+) input of A_1 to be driven more positive than the inverting (−) input, so the output switches to HIGH during this period. Thus, A_1 slices the video signal at approximately the midpoint of the sync amplitude; i.e. the output is a positive-going composite video signal.

R_{12} and C_4 integrate this sync waveform. The time constant is chosen so that the output of A_2 switches LOW only during the vertical interval. R_{17}, which provides feedback and Schmitt-trigger action, is chosen so that A_2's output will remain

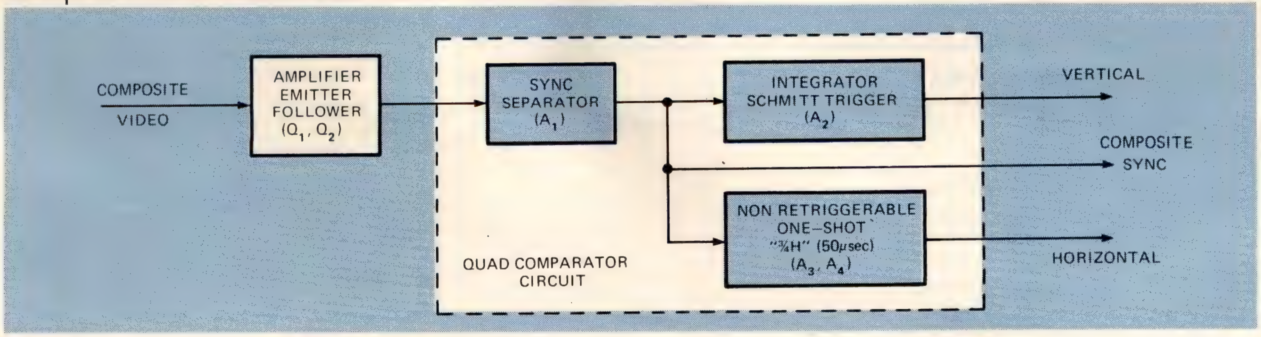

COMPOSITE
VIDEO
AMPLIFIER EMITTER FOLLOWER (Q_1, Q_2)
SYNC SEPARATOR (A_1)
INTEGRATOR SCHMITT TRIGGER (A_2)
VERTICAL
COMPOSITE SYNC
NON RETRIGGERABLE ONE–SHOT "¾H" (50μsec) (A_3, A_4)
HORIZONTAL
QUAD COMPARATOR CIRCUIT

Fig. 1—After composite sync information is separated from the composite video, the horizontal and vertical rate signals are separated from the composite sync.

LOW until the end of the vertical interval. As a result, the output of A_2 is the negative-going vertical rate component.

Eliminating the 2× component

A_3 and A_4 are connected as a nonretriggerable 1-shot multivibrator with a time constant of about 3/4H (≈50 μsec). The differentiated positive sync trigger switches A_3 LOW. C_6 then discharges rapidly to zero, A_4 switches HIGH, and feedback via R_{22} causes A_3 to return to HIGH. C_6, chosen small enough to be discharged completely before A_4 switches HIGH, charges through R_{23} and switches A_4 LOW when the trip point is reached (≈50 μsec). Only after A_4 goes LOW is the input ready to accept the next sync trigger.

The nonretriggerable action of the A_3/A_4 one-shot eliminates the 2× horizontal rate component present in the sync signal during the vertical interval. Thus, the output of A_4 is the positive-going horizontal rate component, completing the necessary signal separations.□

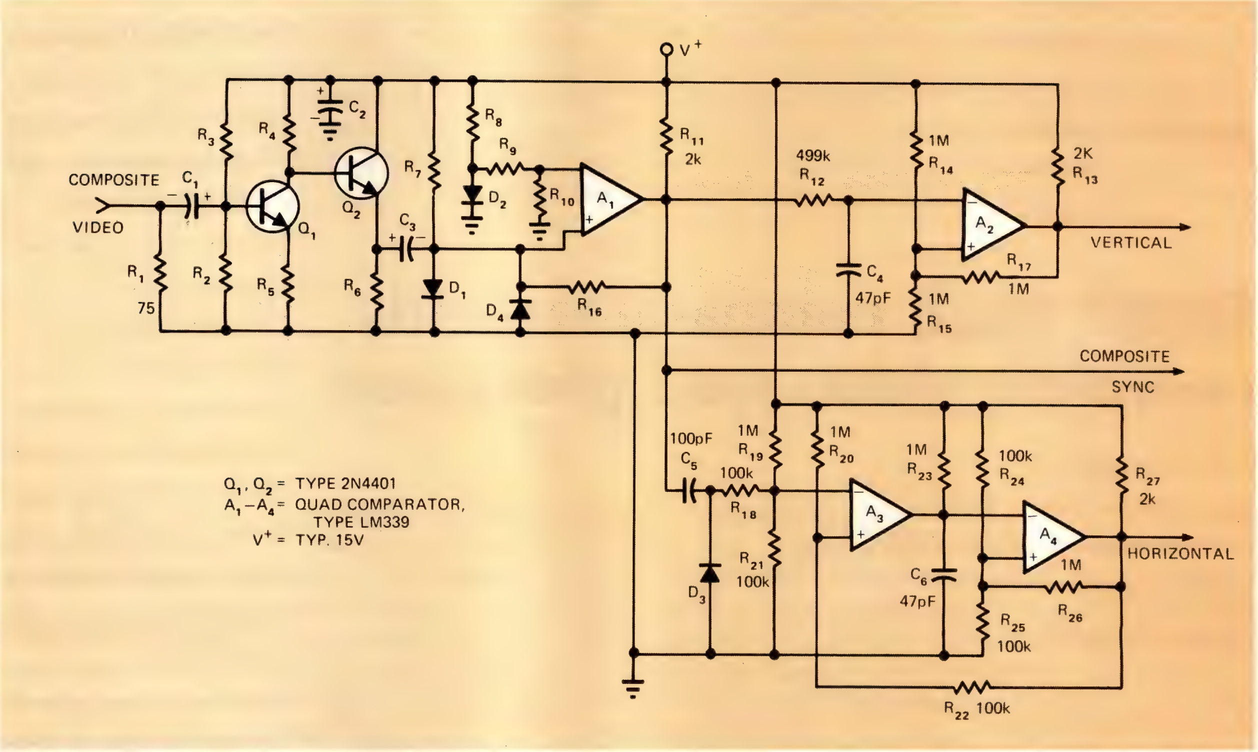


Fig. 2—Nonretriggerable one shot formed by A_3 and A_4 develops the positive-going horizontal rate component. Feedback gives A_2 some Schmitt-trigger action. Complete processor takes advantage of LM339's medium speed capability and single-supply operation.

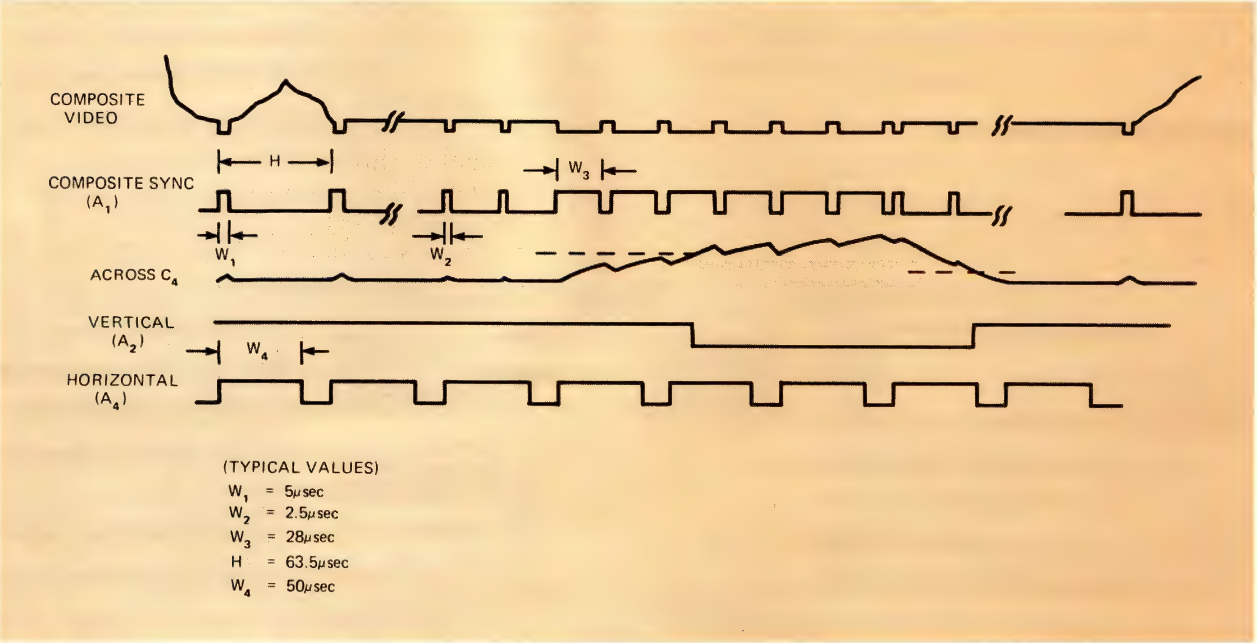


Fig. 3—Waveforms tell the story of circuit operation perhaps better than words can.

Voltage and current programmable power supply offers high resolution

Ralph Tenny

The specifications for this versatile programmable power supply are listed in **Table 1**. Actually two versions are offered. The basic model is both current and voltage programmable. The alternate circuit substitutes current limiting for current modulation capability.

Referring to the schematic diagram (**Fig. 1**), observe that A_1 generates the master voltage reference. Basically, the entire circuit except the current modulator tracks this section's 0.01%/°C drift. For greater stability, a reference zener should be used in place of the 1N752 shown.

A_2 buffers the 10k control pot. It also provides a stiff drive point for input B's external voltage drive. This makes possible precise voltage ratios.

Amplifier A_3, plus outboard pass transistor Q_1, sets the output voltage at twice the value

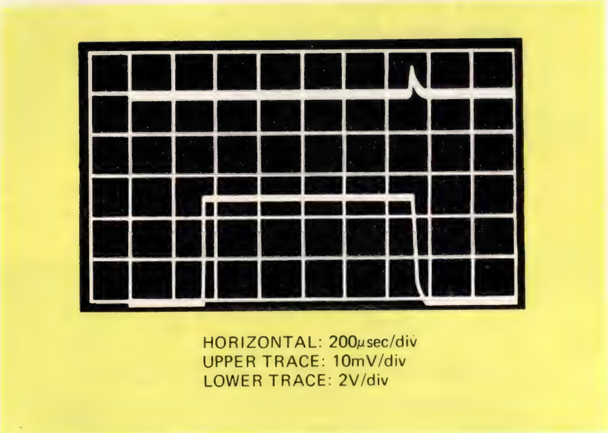
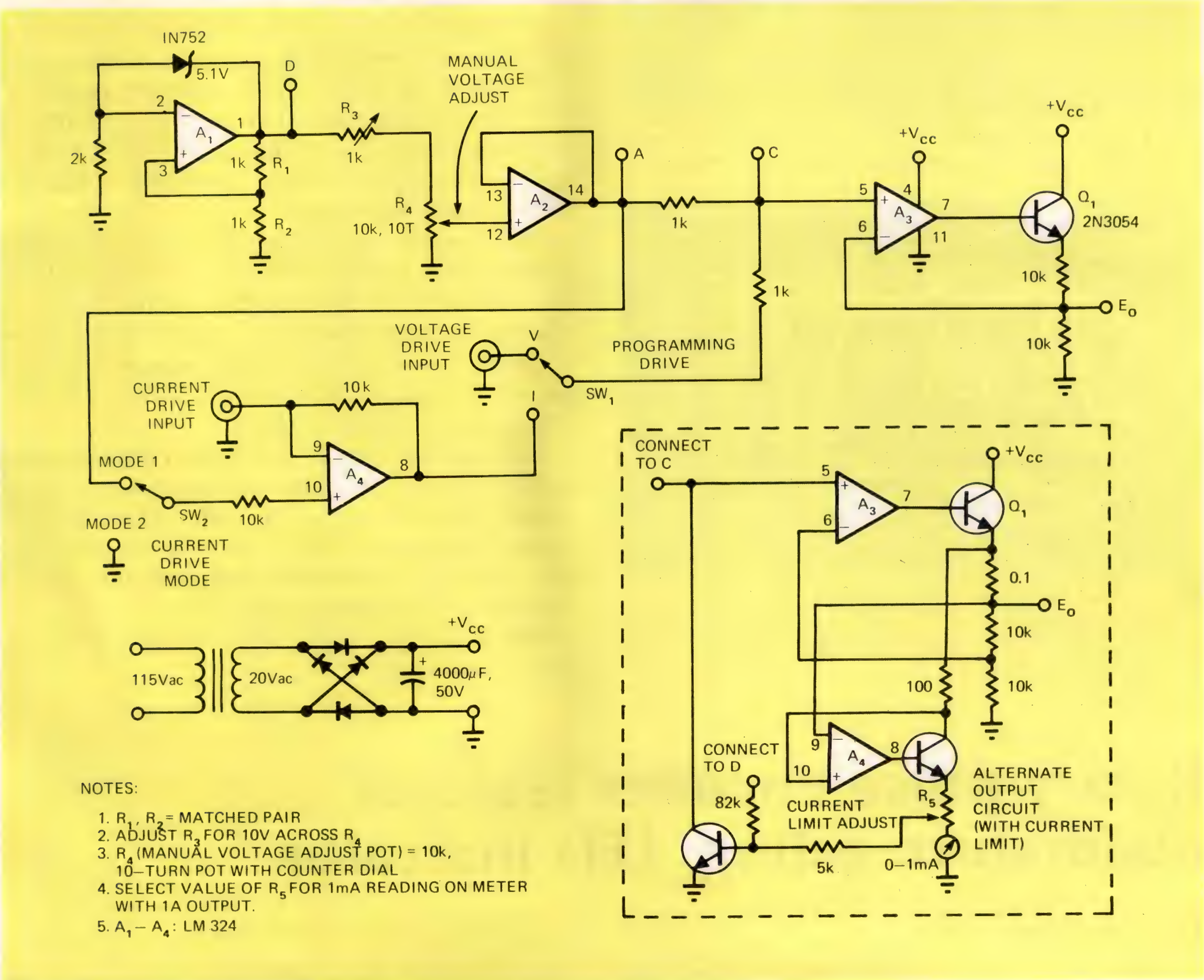


Fig. 2—A 500 mA load pulse at PRF of 15 Hz is shown on lower trace. Upper trace is output at 10 mV/div. sensitivity. Not visible is 2 μsec wide, 20 mV p-p spike coincident with rising edge of load pulse.



NOTES:

1. R_1, R_2 = MATCHED PAIR
2. ADJUST R_3 FOR 10V ACROSS R_4
3. R_4 (MANUAL VOLTAGE ADJUST POT) = 10k, 10–TURN POT WITH COUNTER DIAL
4. SELECT VALUE OF R_5 FOR 1mA READING ON METER WITH 1A OUTPUT.
5. A_1 – A_4: LM 324

Fig. 1—Current-limit protection can be substituted for current programmability if A_3 and A_4 are used as indicated in the ALTERNATE OUTPUT CIRCUIT diagram. For critical applications, substitution of a reference zener for the 1N752 will decrease the supply's drift.

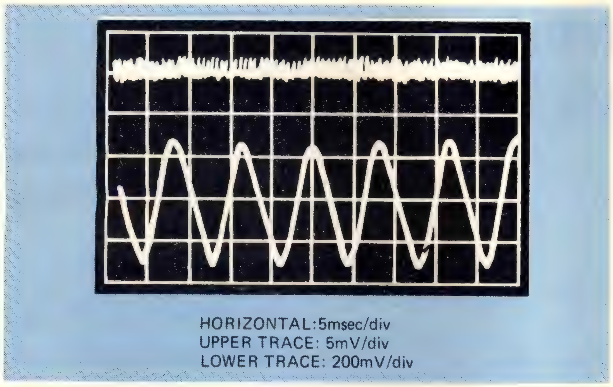

HORIZONTAL: 5msec/div
UPPER TRACE: 5mV/div
LOWER TRACE: 200mV/div

Fig. 3—Output ripple is low. Upper trace is 10V output with 500-mA load. Lower trace is input ripple—approximately 600 mV p-p.

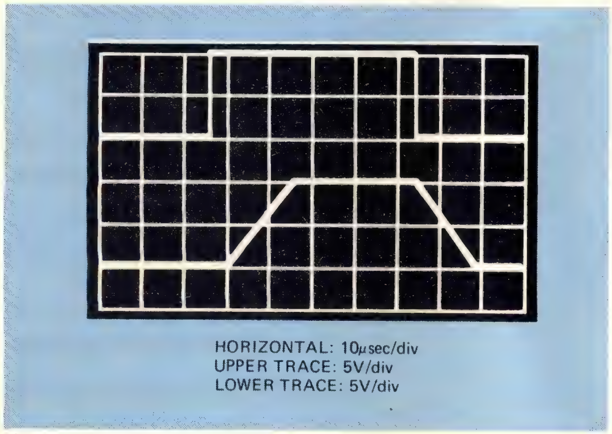

HORIZONTAL: 10μsec/div
UPPER TRACE: 5V/div
LOWER TRACE: 5V/div

Fig. 4—Slew rate exceeds 0.6V/μsec, as lower trace shows. Upper trace is the 10 kHz square wave applied to the voltage drive input.

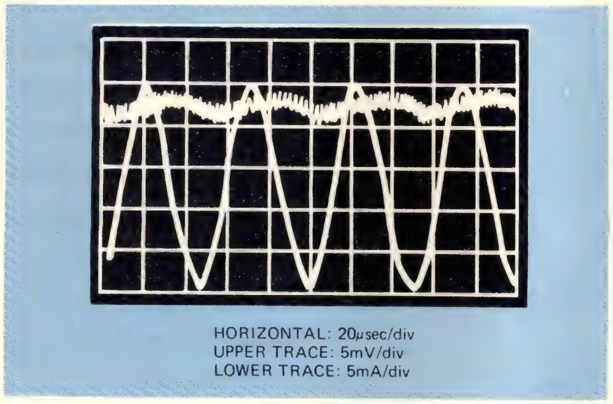

HORIZONTAL: 20μsec/div
UPPER TRACE: 5mV/div
LOWER TRACE: 5mA/div

Fig. 5—Load regulation is better than 0.02%, from 0 to 1A. Lower trace shows a 20 kHz, 25 mA p-p load current imposed on a 17 mA dc load. Upper trace shows resulting output voltage ripple.

TABLE 1

PROGRAMMABLE POWER SUPPLY PERFORMANCE SPECIFICATIONS

INPUT	MINIMUM	13V OR (V_o + 3V), WHICHEVER IS GREATER
	MAXIMUM	30V
OUTPUT	VOLTAGE	0.5 TO 20V
	CURRENT	0 TO 1A
LOAD REGULATION		0.02%, 0–1A @ 10V OUTPUT
LINE REGULATION		0.02%, 13–30V @ 500mA LOAD AND 10V OUTPUT
RIPPLE AND NOISE		3mV $_{p-p}$, 0–1A LOAD
OPERATING TEMPERATURE		0–60°C, CONTINGENT UPON PROPER HEATSINKING OF PASS TRANSISTOR
OUTPUT IMPEDANCE		<0.2Ω, dc TO 20kHz
SETTING RESOLUTION		<20mV WITH 10–TURN POTENTIOMETER
PROGRAMMING SENSITIVITY	VOLTAGE	1V/V
	CURRENT	10mV/μA
SLEW RATE		0.6V/μsec

appearing at point C. Thus, with a reference of 0 to 10V, output range is 0.5V, min.; 20V, max. If adequate heatsinking is maintained for the pass transistor and a 3V min. instantaneous drop across it is provided, this supply will deliver the full rated 1A current over 0 to +60°C.

A_4 has two possible uses

The fourth section of the LM324 can be used in either of two ways: as a current modulator (that must be fed at point E from a current source of 10V min. compliance), or as a current limit/meter drive circuit (as shown under "ALTERNATE OUTPUT"). The latter is self explanatory, but the former needs discussion.

The current modulator has two operating modes. With point F (the noninverting input of A_4) connected to point A (the output of A_2), an external current source or current sink can be connected to input E. A source will decrease the output voltage, while a sink will increase output above the manual pot setting.

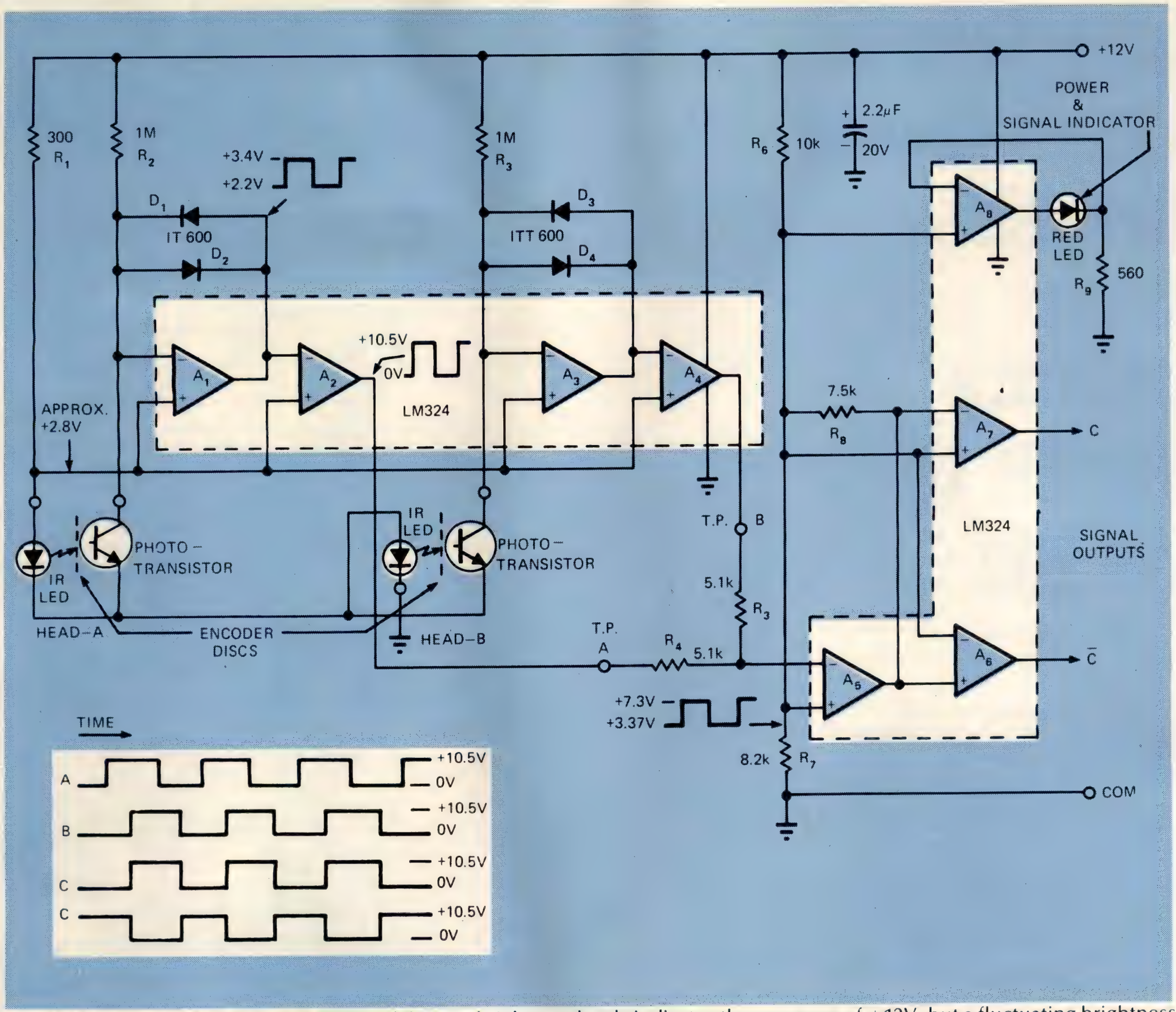
With point F tied to common, output voltage will be 1/2 the manual pot setting and an external current sink connected to E will cause increased output voltage. In this configuration with the manual control set to zero, input current from 0-2 mA will sweep the output to 20V.

Figs. 2-5 show scope traces of various performance parameters. □

Rotary pulse encoder features quadrature gating, LED indicator

Frank W. Colver

In this circuit, two LM324's amplify, shape, gate and buffer the signals from a pair of photoheads that provide quadrature signals from a rotary disk shaft encoder. Quad amplifiers were used because of the low level of common mode voltage at the inputs of A_1-A_5. Of course, they also keep the



Single LED serves a dual function. Either of the two brightness levels indicates the presence of +12V, but a fluctuating brightness indicates an output signal when the encoder is turned slowly. Quadrature gating prevents spurious outputs.

physical size of the encoder small.

Operation is from 12V because the circuit was used with a CMOS system. If resistor values were changed, the encoder would work well in a 5V system.

A_1 and A_3 are high-speed current amplifiers for phototransistors A and B. Feedback is 100% when diodes D_1, D_2, D_3 and D_4 conduct. This permits the phototransistors to operate with no voltage change across them, thereby increasing speed.

A_2 and A_4 are used as comparators. They generate logic-level square waves from the 1.2V p-p signal outputs of A_1 and A_3.

An ounce of prevention...

Spurious outputs from the encoder during the on/off transition of the phototransistors can cause serious system difficulties. A quadrature gating scheme prevents such problems. An output change occurs only when the outputs of A_2 and A_4 are the same polarity. The encoder output does **not** change when A_2 and A_4 go from equal to not equal.

This gating and latch function is accomplished by using R_4 and R_5 as an analog AND gate feeding into A_5. Since A_5, R_6, R_7 and R_8 are connected as a Schmitt-trigger circuit, A_5's output cannot change state until inputs A and B are simultaneously either ZERO or ONE.

A_6 and A_7 output buffers provide both true and complement outputs and isolate A_5 from the output cable. This prevents loading and noise triggering of the Schmitt trigger.

The visible LED driven by A_8 serves both as a power indicator and a signal indicator. There are two brightness levels, either of which indicates the presence of +12V. But modulation of the brightness shows the presence of an output signal when the encoder is turned slowly. □

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Electronic Component

Leadtime Index

September 1974

	LEADTIME IN WEEKS MIN.	MAX.	TREND
CAPACITORS			
Ceramic	8	25	▲
Electrolytic			
aluminum	11	33	▲
tantalum	10	29	▲
Film	7	17	▲
Mica	6	20	▼
Paper	7	15	▲
Trimming	6	14	▲
CONNECTORS			
Coaxial	5	11	▼
Multipin circular			
high-density	10	16	▼
standard	7	11	=
Printed-circuit	6	14	▲
Rack & panel	6	12	=
INTEGRATED CIRCUITS			
DTL	13	25	▼
ECL	5	15	▼
TTL	11	25	▼
MOS	8	20	▲
CMOS	6	17	▼
Op amps (monolithic)	5	18	▼
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Op amps (hybrid & discrete)	8	18	▲
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General-purpose	6	10	=
Stepping	8	16	▲
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Solid-state	5	10	▼

	LEADTIME IN WEEKS MIN.	MAX.	TREND
RESISTORS, FIXED			
Composition	5	13	▼
Dep.-carbon & carbon-film	12	21	▲
Metal-film	8	23	▲
Wirewound	7	16	▼
RESISTORS, VARIABLE			
Nonwirewound			
nonprecision	2	11	▼
precision	4	14	▼
Trimmers	4	12	=
Wirewound			
nonprecision	2	10	▼
precision	5	13	▼
trimmers	2	8	▼
SEMICONDUCTORS			
FET's	5	12	▼
Power rectifiers	5	11	▼
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SCR's & triacs	6	15	▼
Silicon switching transistors	6	14	▼
Switching diodes	9	21	▲
Zeners	6	16	▼
SWITCHES			
Lighted pushbutton	6	15	▲
Pushbutton	5	13	▲
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WIRE & CABLE	8	19	▼
PANEL METERS	6	16	▼
LIGHT-EMITTING DIODES	4	8	▼
READOUTS & DISPLAYS	5	9	▼

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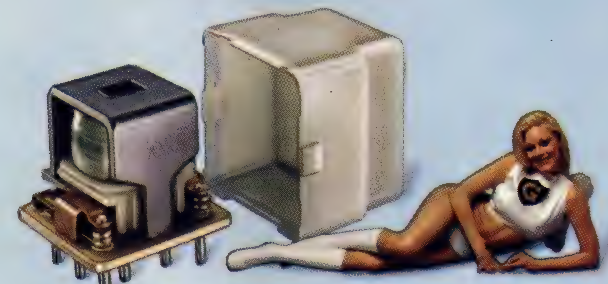

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Circle No. 38

Designers' Guide to: Active filters—Part 2

Proper application of active filters is not elementary. It requires knowledge of the properties and capabilities of the various types.

Marvin Patterson, Hewlett Packard Co.

Any filter function capable of passive implementation can be realized with an RC active filter design. In Part 1 (Aug. 20, 1974, pg. 83), we developed a technique for synthesizing complex transfer functions by cascading simple sub-functions. The transfer functions discussed were very general, because emphasis was directed toward technique development rather than specific response requirements. Having laid this foundation, we can now start to build on it by considering the practical rather than the theoretical aspects of RC active filter design.

The wide variety of response requirements has given birth to a number of classical filter types. Because of their unique properties, each type has been considered the optimum solution for specific response requirements. Before jumping into a design example, it might be beneficial to briefly review the characteristics and lowpass response design criteria of some of the "old standard" filter types.

Fast response with no overshoot

A Gaussian lowpass filter gives a critically damped response to a step input function. This filter offers the fastest risetime and sharpest frequency rolloff possible without amplitude overshoot. Consequently, it might be considered optimum for filtering a signal where exact knowledge of an input pulse amplitude is of prime importance.

N^{th}-order Gaussian filters are equivalent to cascading n single-pole lowpass sections. Consequently, the response is given by:

$$A(s) = \left[\frac{a}{(s + a)}\right]^n$$

TABLE 1

LOCATION OF POLES FOR BESSEL LOWPASS FILTERS
CUTOFF FREQUENCY, ω_c, NORMALIZED TO 1.0 RADIAN/SEC

n	POLE LOCATIONS
1	−1.000
2	−1.103 ± j0.637
3	−1.327; −1.051 ± j1.002
4	−1.360 ± j0.407; −0.988 ± j1.248
5	−1.507; −1.385 ± j0.720; 0.961 ± j1.476
6	−1.537 ± j0.321; −1.384 ± j0.973; −0.932 ± j1.664
7	−1.685; −1.613 ± j0.590; −1.380 ± j1.192 −0.910 ± j1.838
8	−1.763 ± j0.274; −1.642 ± j0.825; −1.378 ± j1.393; −0.896 ± j2.004

where $s = -a$ is the location of all n poles on the negative real axis of the s-plane. For steady-state sinusoidal signals, $s = j\omega$ and:

$$A(j\omega) = \frac{a^n \angle \theta(\omega)}{(\omega^2 + a^2)^{n/2}} \qquad (23)$$

$$\theta(j\omega) = -n\,\mathrm{Tan}^{-1}\left(\frac{\omega}{a}\right) \qquad (24)$$

At the 3 dB cutoff frequency ω_c:

$$\frac{a^n}{(\omega_c^2 + a^2)^{n/2}} = \frac{1}{\sqrt{2}} \qquad (25)$$

solving for ω_c yields:

$$\omega_c = (2^{1/n} - 1)^{1/2}a \qquad (26)$$

When you need passband flatness

A Butterworth lowpass filter gives the most constant amplitude response over the pass band, often referred to as "maximally flat" amplitude response. Outside of the pass band the attenuation slope of this filter rapidly increases, achieving the asymptotic rate of −6 dB/octave/pole at a much lower frequency than the Gaussian case. Because of these characteristics, Butterworth filters might be considered optimum where the input power spectrum in the pass band is of primary importance and good rejection outside the pass band is required.

However, a step response having considerable overshoot accompanies these desirable spectral characteristics. The amount of overshoot ranges from 4.3% for a 2-pole network to 12.8% for five poles.

The general transfer function for an n-pole lowpass filter can be expressed as:

$$A(s) = \frac{H}{s^n + a_1 s^{n-1} + \cdots d_n} \tag{27}$$

The magnitude of this function for sinusoidal signals takes the form **(Ref. 4)**:

$$|A(j\omega)| = \frac{H}{(\omega^{2n} + A_1\omega^{2n-2} + \cdots A_n)^{1/2}} \tag{28}$$

For constant amplitude response, the ideal slope of this function throughout the pass band would be zero. The closest approximation to this condition is achieved when as many derivatives as possible of **Eq. 28** are made equal to zero at $\omega = 0$. When this is done, **Eq. 28** becomes **(Ref. 5)**:

$$|A(j\omega)| = \frac{H}{(\omega^{2n} + \omega_0^{2n})^{1/2}} \tag{29}$$

where

$$\omega_0^{2n} = A_n$$

$$\text{At } \omega = 0 \qquad |A(j\omega)| = \frac{H}{\omega_0^n}$$

$$\text{At } \omega = \omega_0 \qquad |A(j\omega)| = \frac{H}{\sqrt{2}\,\omega_0^n}$$

The 3-dB cutoff, ω_c, is thus independent of n and is given by:

$$\omega_c = \omega_0 \tag{30}$$

The poles of the transfer function that yield **Eq. 29** can be shown to be equally spaced around a semicircle of radius ω_0 in the left half of the s-plane. If the number of poles, n, is odd, a pole exists at $s = -\omega_0$ and all other poles are located on the semicircle separated from each other by π/n radians. If n is even, no poles exist on the negative real axis. The first pair occur on the semicircle at $\pi/2n$ radians above and below the negative real axis. The other poles are spaced at π/n intervals from the first two. **Fig. 9** illustrates these rules for 5- and 6-pole Butterworth filters.

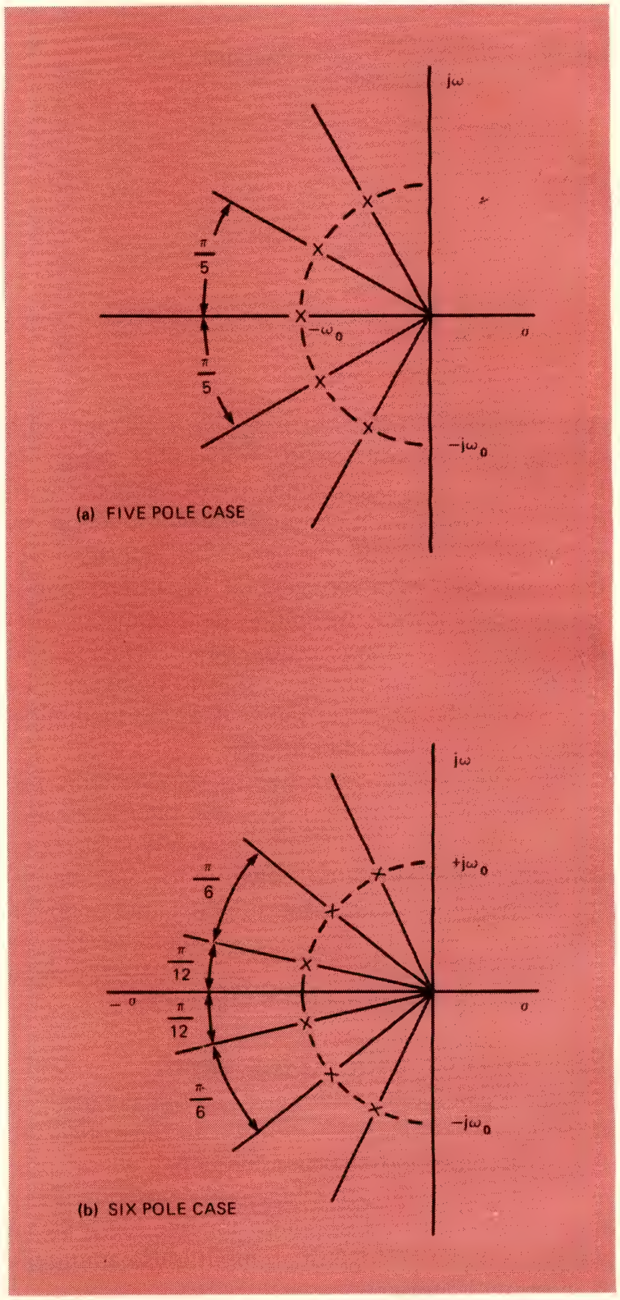


Fig. 9—Butterworth pole-zero plots will show a negative real pole only when the number of poles, n, is odd.

Preserving the input waveform

A filtered signal differs from the unfiltered input because of two effects. First, the filter reduces the amplitude of harmonics contained in the input signal that lie outside the filter pass band. Second, the filter generally delays the various input harmonics by differing amounts causing delay distortion of the output

TABLE 2

INITIAL TIME DELAY, T_0, AND DELAY VARIATION AS A FUNCTION OF n AND FREQUENCY FOR BESSEL LOWPASS FILTERS. CUTOFF FREQUENCY, ω_0, NORMALIZED TO 1.0 RADIAN/SEC

		Value of ω where delay equals:			
n	T_0 (Sec)	0.99 T_0	0.9 T_0	0.8 T_0	0.5 T_0
1	1.00	0.10	0.34	0.50	1.00
2	1.36	0.412	0.801	1.022	1.618
3	1.75	0.691	1.109	1.309	1.943
4	2.13	0.906	1.333	1.554	2.160
5	2.42	1.120	1.554	1.736	2.388
6	2.70	1.304	1.737	2.204	2.581
7	2.95	1.478	1.912	2.136	2.763
8	3.17	1.647	2.079	2.303	2.943

waveform. Even when the pass band is widened sufficiently to include all significant input harmonics, most filters will noticeably alter the input waveform because of nonuniform harmonic delay.

The Bessel lowpass filter minimizes such an effect. This class of filter provides the most linear phase vs. frequency characteristic. Since the time delay of a filter is equal to minus the rate of change of its phase shift with respect to angular frequency, Bessel filters provide a maximally flat time delay. Therefore, harmonics present at the input of a Bessel filter will tend to appear at the output in the same time relationship, thus preserving the input waveform as nearly as possible. Consequently, Bessel filters are useful in applications where knowledge of the input waveform takes on primary importance.

As in many other cases, optimizing one characteristic generally requires tradeoffs. Bessel filters possess a modest overshoot that peaks at 0.83% for four poles and decreases in both higher and lower order filters. The amplitude response of Bessel filters rolls off sharper than Gaussian filters but take longer to approach the asymptotic amplitude slope than Butterworth filters.

Bessel lowpass filters have the general transfer function given by **Eq. 27.** The exact form of the denominator that produces maximally flat time delay characteristics is derived from nth order Bessel polynomials **(Ref. 6).** Corresponding locations of the n poles do not follow a convenient analytical relationship like the previous two cases, and can best be provided in tabular form. **Table 1** gives normalized pole locations for first through eighth order Bessel filters. **Table 2** shows time delay characteristics as a function of frequency and the number of poles. To obtain the pole locations for a filter of cutoff frequency ω_c, simply multiply the coordinates in **Table 1** by ω_c. **Table 2** can be applied by dividing the listed time delays by ω_c and multiplying the listed frequencies by ω_c.

For sharp cutoff applications

Chebyshev lowpass filters provide a more accurate approximation to the ideal lowpass amplitude vs. frequency characteristic. The amplitude response is not flat in the pass band but, instead, cycles as a function of frequency by an amount predetermined in the design. The attenuation slope vs. frequency outside the pass band is initially much steeper than the asymptotic slope and gradually reduces to the asymptotic value as frequency tends toward infinity. This type of filter should thus be used when some amplitude variation in the pass band can be tolerated and when a rapid transition to the stop band is desired along with maximum stop-band attenuation.

The analytic form of the Chebyshev amplitude response for sinusoidal steady-state is shown by **Ref. 7**:

$$|A(j\omega)| = \frac{1}{\left[1 + \epsilon C_n^2\left(\frac{\omega}{\omega_p}\right)\right]^{1/2}} \qquad \textbf{(31)}$$

where C_n is the nth-order Chebyshev polynomial, ϵ is a factor that sets the amplitude of the passband amplitude variation, and ω_p is the edge of the pass band. The Chebyshev polynomials are given by:

$$C_n(x) = \mathrm{Cos}(n\ \mathrm{Cos}^{-1}x) \text{ for } -1 \leq x \leq 1 \qquad \textbf{(32)}$$

or

$$C_n(x) = \mathrm{Cosh}(n\ \mathrm{Cosh}^{-1}x) \text{ for } |x| > 1 \qquad \textbf{(33)}$$

These general equations translate into the following polynomials:

$$\begin{aligned} C_1(x) &= x \\ C_2(x) &= 2x^2 - 1 \\ C_3(x) &= 4x^3 - 3x \\ C_4(x) &= 8x^4 - 8x^2 + 1 \\ C_{n+1}(x) &= 2xC_n - C_{n-1} \end{aligned} \qquad \textbf{(34)}$$

Fig. 10 shows a typical Chebyshev amplitude response. The magnitude of the ripple in dB, δ, is given by:

$$\delta = 10\ \mathrm{Log}(1 + \epsilon) \qquad \textbf{(35)}$$

Table 3 shows the values of ϵ corresponding to common values of δ. To determine the pole locations for an n^{th}-order Chebyshev filter, first calculate the design parameter, a, such that:

$$a = \frac{1}{n}\,\text{Sinh}^{-1}\left(\frac{1}{\sqrt{\epsilon}}\right) \tag{36}$$

The approximate 3-dB cutoff frequency will be given by:

$$\omega_c \simeq \omega_p\,\text{Cosh}(a) \text{ for } \epsilon \ll 1$$

Next, draw a circle of radius ω_p Cosh (a), centered at the origin of the s-plane as in **Fig. 11.** Locate n poles on this circle according to the rules given for the Butterworth case. Finally, multiply the real part of the coordinates for each pole by Tanh (a). This, in effect, moves the poles horizontally toward the $j\omega$ axis to their final location on an ellipse with major axis equal to ω_p Cosh (a), and minor axis equal to ω_p Sinh (a).

Implementing a lowpass filter

We have, to this point, discussed how to locate network poles for various optimum types of lowpass response. Knowing the location of these poles completely defines the denominator of the corresponding transfer function. For a unity-gain lowpass function, the numerator should equal the denominator at s = 0. The resulting transfer function can thus be written as:

$$A(s) = \frac{s_0 s_1 s_1^* \cdots s_m s_m^*}{(s+s_0)(s+s_1)(s+s_1^*) \cdots (s+s_m)(s+s_m^*)} \tag{37}$$

where s_0, s_1, s_1^*, $\cdots$ s_m^* are determined from the previously described techniques to provide the desired type of response (* denotes the complex conjugate).

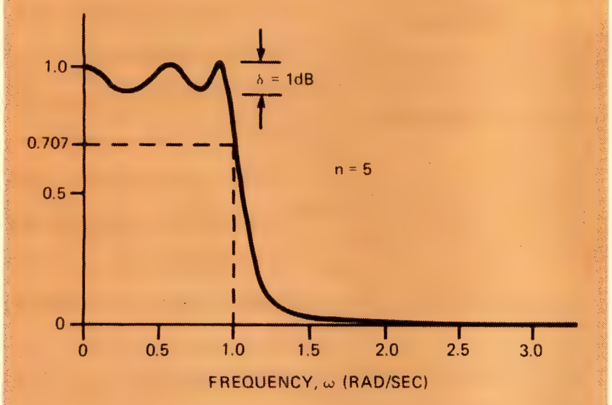


Fig. 10—Chebyshev lowpass filters more nearly approximate the ideal amplitude vs. frequency characteristics.

TABLE 3

RIPPLE AMPLITUDE VS. ϵ

δ (dB)	ϵ
0.1	0.0233
0.2	0.0471
0.5	0.122
1.0	0.259
2.0	0.585
3.0	0.995

An alternate form of **Eq. 37,** called the lowpass prototype, is obtained by dividing both the numerator and denominator by $(\omega_c)^n$. This yields:

$$A(p) = \frac{p_0 p_1 p_1^* \cdots p_m p_m^*}{(p+p_0)(p+p_1)(p+p_1^*) \cdots (p+p_m)(p+p_m^*)} \tag{38}$$

where

$$p = \frac{s}{\omega_c} = \alpha + jx \tag{39}$$

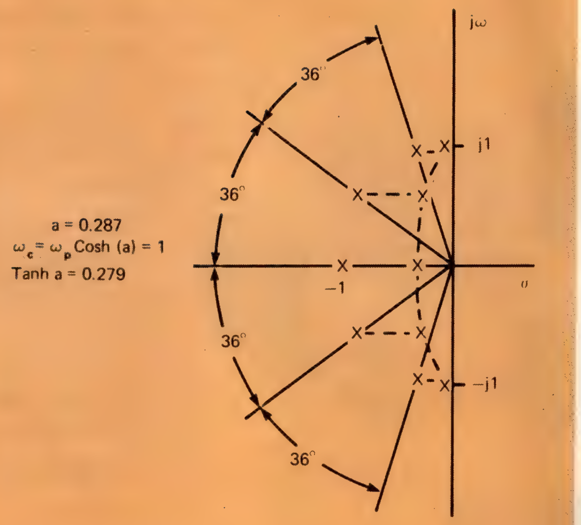
and where p_0 through p_m^* equals s_0/ω_c through s_m^*/ω_c, respectively. The coefficients and pole locations in **Eq. 37** vary with ω_c. Since **Eq. 38** has been normalized, the coefficients and pole locations, with respect to the variable p, are independent of ω_c. They depend only on the type of lowpass response. For example, a single lowpass prototype transfer function **(Eq. 38)** applies to all 1 db-ripple, 5-pole Chebyshev filters. Once known, the transfer function for such a filter at any ω_c can be obtained by multiplying the numerator and denominator of the lowpass prototype by $(\omega_c)^n$.

The transfer function of **Eq. 37** can be factored into the following general sub-functions:

$$A_0(s) = \frac{s_0}{(s+s_0)} \tag{40}$$

$$A_i(s) = \frac{s_i s_i^*}{(s+s_i)(s+s_i^*)} \tag{41}$$

The function $A_0(s)$ can be implemented with a single passive RC lowpass section. If a number of such functions are to be cascaded for a Gaussian response, use an active implementation to avoid loading effects. The active 2-pole lowpass section shown in **Fig. 6,** Part 1, can be designed to provide two coincident real poles. This circuit also can be altered to provide the general form of response required by **Eq. 41.** Any type of lowpass filter described herein can thus be implemented by a series of properly designed active 2-pole circuits. If required, the odd real pole can be realized with a passive RC lowpass section. ☐



Butterworth Poles	Chebyshev Poles
−1.00	−0.279
−0.81 ± j0.59	−0.225 ± j0.59
−0.31 ± j0.95	−0.086 ± j0.95

Fig. 11—Construction of a Chebyshev pole-zero plot uses Butterworth rules to initialize pole locations.

Part 3 of this series, covering the techniques of lowpass prototype transformations, will appear in the Oct. 20, 1974 issue.

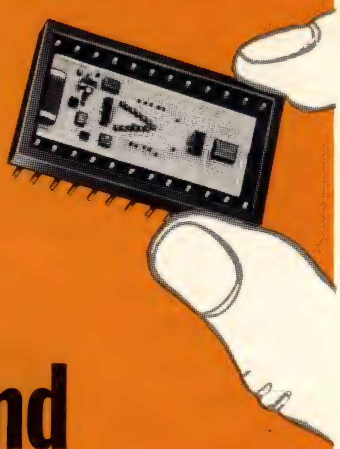
References

4. Van Valkenburg, M. E., "Network Analysis," Prentice Hall, 1955.

5. Ibid.

6. Shea, Richard F., "Amplifier Handbook," McGraw-Hill, 1966.

7. Van Valkenburg, M. E., "Network Analysis," Prentice Hall, 1955.



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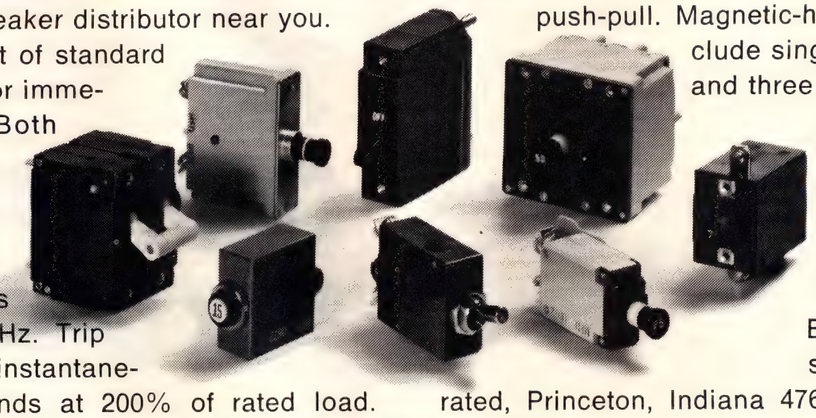

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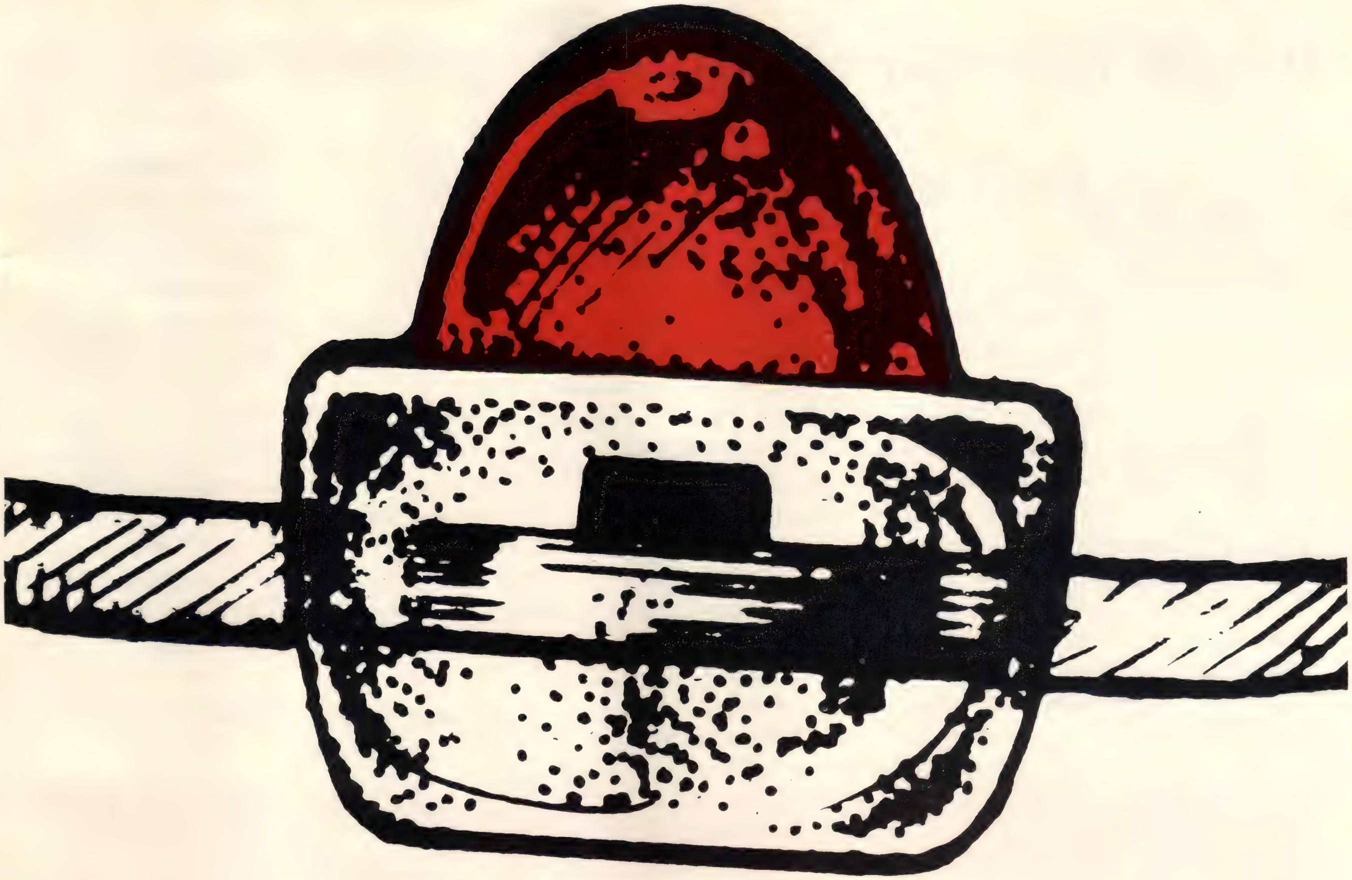

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Decode ripple counter outputs the "glitchless" way

T. M. Farr, Jr.
Telex Computer Products Inc., Tulsa, OK

A common type of control or sequencing equipment consists of a clock driving a counter, with associated decoding gates giving outputs at specific count levels. A typical problem with this scheme is false outputs, or "glitches" from the decoding gates as the count ripples down the counter. This is most severe when the counter is implemented in the easiest and least expensive way—a binary counter made up of "T" flip-flops.

One solution is to convert to a counter utilizing the Gray code. In this code only one bit changes state with each clock pulse, and decoding gates connected to this counter do not produce "glitches." Unfortunately, Gray code counters are difficult to implement, and the difficulty grows as the required counter length increases.

Fig. 1 shows the most common method of converting the binary counter output to Gray code. Unfortunately, the exclusive-OR gates used still suffer from the very problem we are trying to solve. That is, whenever both inputs to one of these gates change simultaneously, the output "glitches," causing the decoding gates to do likewise.

Fig. 2 shows the solution to this problem. This circuit produces a "glitchless" Gray code output from a counter of any length. The "Q" output of each stage of the counter (except the last one) is connected to the "T" input of the conversion flip-flop. The outputs (**Fig. 3**) thus produced will be a cyclic Gray code of the most common form, normally referred to as "THE Gray" code. □

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Circle 160

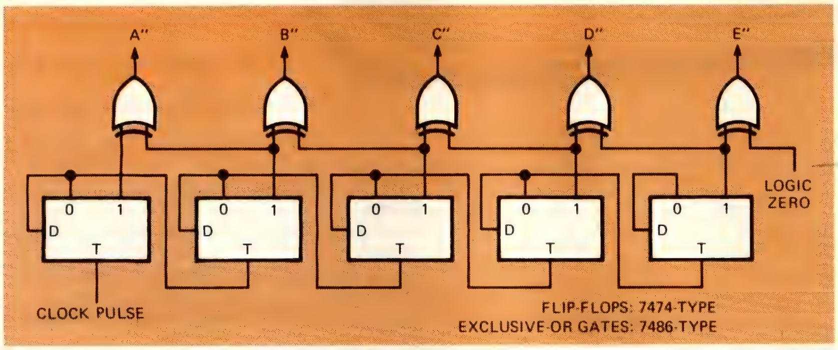

Fig. 1—When both inputs to one of the exclusive-OR gates change simultaneously, this binary-to-Gray code converter will produce a glitch.

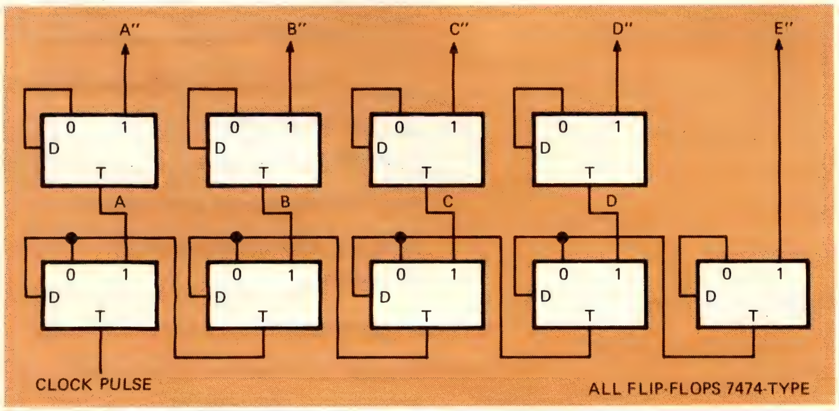

Fig. 2—A glitchless Gray code output of the most common form (also referred to as "THE Gray" code) is produced by this circuit. Counter can be of any length.

DECIMAL	BINARY E D C B A	GRAY E D C B A
0	0 0 0 0 0	0 0 0 0 0
1	0 0 0 0 1	0 0 0 0 1
2	0 0 0 1 0	0 0 0 1 1
3	0 0 0 1 1	0 0 0 1 0
4	0 0 1 0 0	0 0 1 1 0
5	0 0 1 0 1	0 0 1 1 1
6	0 0 1 1 0	0 0 1 0 1
7	0 0 1 1 1	0 0 1 0 0
8	0 1 0 0 0	0 1 1 0 0
9	0 1 0 0 1	0 1 1 0 1
10	0 1 0 1 0	0 1 1 1 1
11	0 1 0 1 1	0 1 1 1 0
12	0 1 1 0 0	0 1 0 1 0
13	0 1 1 0 1	0 1 0 1 1
14	0 1 1 1 0	0 1 0 0 1
15	0 1 1 1 1	0 1 0 0 0
16	1 0 0 0 0	1 1 0 0 0
17	1 0 0 0 1	1 1 0 0 1
18	1 0 0 1 0	1 1 0 1 1
19	1 0 0 1 1	1 1 0 1 0
20	1 0 1 0 0	1 1 1 1 0
21	1 0 1 0 1	1 1 1 1 1
22	1 0 1 1 0	1 1 1 0 1
23	1 0 1 1 1	1 1 1 0 0
24	1 1 0 0 0	1 0 1 0 0
25	1 1 0 0 1	1 0 1 0 1
26	1 1 0 1 0	1 0 1 1 1
27	1 1 0 1 1	1 0 1 1 0
28	1 1 1 0 0	1 0 0 1 0
29	1 1 1 0 1	1 0 0 1 1
30	1 1 1 1 0	1 0 0 0 1
31	1 1 1 1 1	1 0 0 0 0

Fig. 3—Output of the circuits of **Figs. 1** and **2** is shown for reference.

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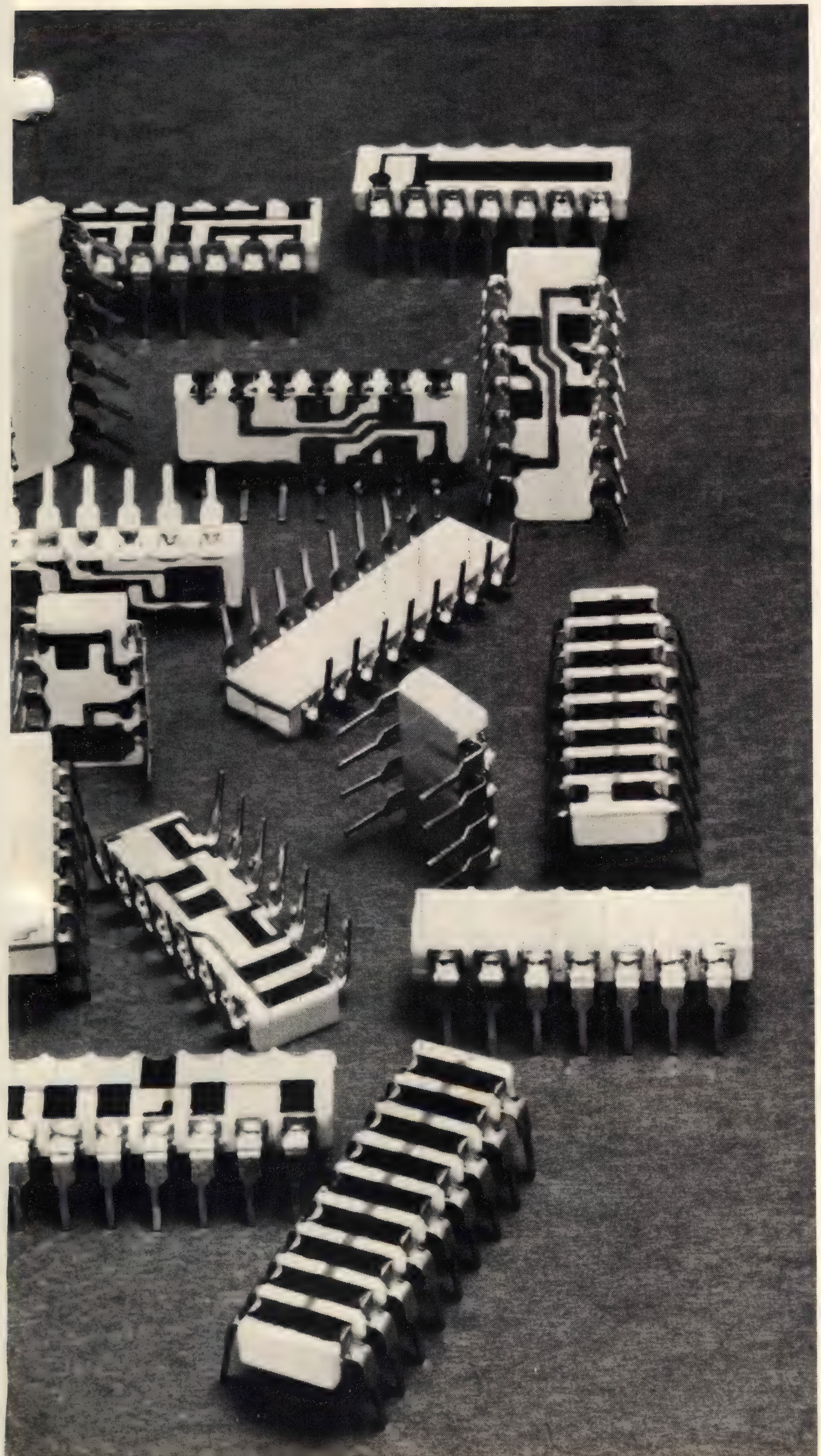

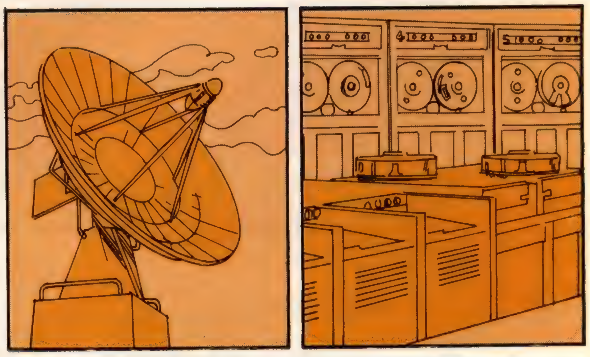

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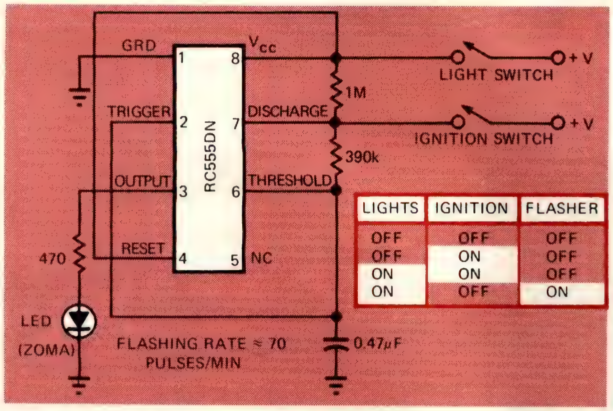
Simple LED flasher is controllable

Gordon H. Buckman,
Boeing Co., Seattle, WA

This circuit was originally designed to be used as a flasher for a "headlights on" warning system. However, it could also be used for a variety of other applications, such as an over-range indicator or a high-temperature warning.



LIGHTS	IGNITION	FLASHER
OFF	OFF	OFF
OFF	ON	OFF
ON	ON	OFF
ON	OFF	ON

This "headlights on" warning system flashes the LED approximately 70 times/minute if your lights are ON and ignition OFF. Circuit takes advantage of the 555's wide operating voltage capability.

Normally, a flasher with control requires an oscillator source plus a transistor or relay to provide the control function. In this approach, though, you need only one active component, plus a capacitor, LED and three resistors. The active component, a 555 timer, is connected as an astable multivibrator. It pulses the LED at approximately 70 pulses/minute with the component values shown.

When the discharge terminal is connected to +V, the output will be held LOW and the LED will remain OFF. Removing this voltage allows the timer to return to its astable state and flash LED.

The table defines the circuit operation when used as a "headlights on" warning system. This automotive application takes good advantage of the wide operating voltage capability of the 555. □

To Vote For This Circuit
Circle 161

Expanded algorithm method derives additional functions

Robert J. Barden,
Douglas P. Collette, Michael Keshura, Jr.
Middletown, RI

A previous article[1] presented an excellent method of finding common logarithms. However, one often needs the ability to perform additional functions such as natural logarithms (ln), anti-logarithms ($\log_{10}^{-1}$ and $\ln^{-1}$), and numbers raised to any power (x^y). Procedures have been developed to permit these functions to be performed quickly and accurately on the common 4-function calculator. In addition, a table is presented which allows increased accuracy if desired.

Basic formulas used for converting bases in logarithms are as follows:

$\log_a x = \log_b x / \log_b a = (\log_b x)(\log_a b)$

$\ln x = \log_e x = \log_{10} x / \log_{10} e = (\log_{10} x)(\log_e 10)$

since $\log_e 10 = 2.302585$

$$\ln x = 2.302585 \log_{10} x \qquad (1)$$

Similarly,

$$\log_{10} x = 0.434294 \ln x \qquad (2)$$

With the above formulas you can easily convert from common logarithms to natural logarithms and back again.

TABLE 1

m	$10^{0.1m_1}$	$10^{0.01m_2}$	$10^{0.001m_3}$	$10^{0.0001m_4}$	$10^{0.00001m_5}$	$10^{0.000001m_6}$
1	1.258925	1.023293	1.002305	1.000230	1.000023	1.0000023
2	1.584893	1.047129	1.004616	1.000461	1.000046	1.0000046
3	1.995262	1.071519	1.006932	1.000691	1.000069	1.0000069
4	2.511886	1.096478	1.009253	1.000921	1.000092	1.0000092
5	3.162278	1.122018	1.011579	1.001152	1.000115	1.0000115
6	3.981072	1.148154	1.013911	1.001383	1.000138	1.0000138
7	5.011872	1.174898	1.016249	1.001613	1.000161	1.0000161
8	6.309573	1.202264	1.018591	1.001844	1.000184	1.0000184
9	7.943282	1.230269	1.020939	1.002074	1.000207	1.0000207

Table 1 can be used for the computation of anti-logs. Given any common logarithm of the form $Cm_1m_2m_3m_4 \ldots$, its anti-logarithm ($\log^{-1}$) can be displayed as $(10^C)(10^{0.1m_1})(10^{0.01m_2})(10^{0.001m_3})(10^{0.0001m_4}) \ldots$ Table 1 provides values for each term up to $10^{0.000001m_6}$. For example, if $m_1 = 6$, the value of $10^{0.1(6)}$ can be found by going to the $10^{0.1m_1}$ column and locating the number corresponding to the number 6 in the m column. Therefore, $10^{0.1(6)} = 3.981072$. A row corresponding to $m = 0$ has not been included since $10^0 = 1$. Further, because the anti-natural log of a number ($\ln^{-1}x$) is simply e raised to the x power (e^x), the necessary computations are a special case of the following paragraph.

Raising a number to any power (x^y) can be derived in the following manner:

if $x^y = B$

then $\log x^y = y \log x = \log B$

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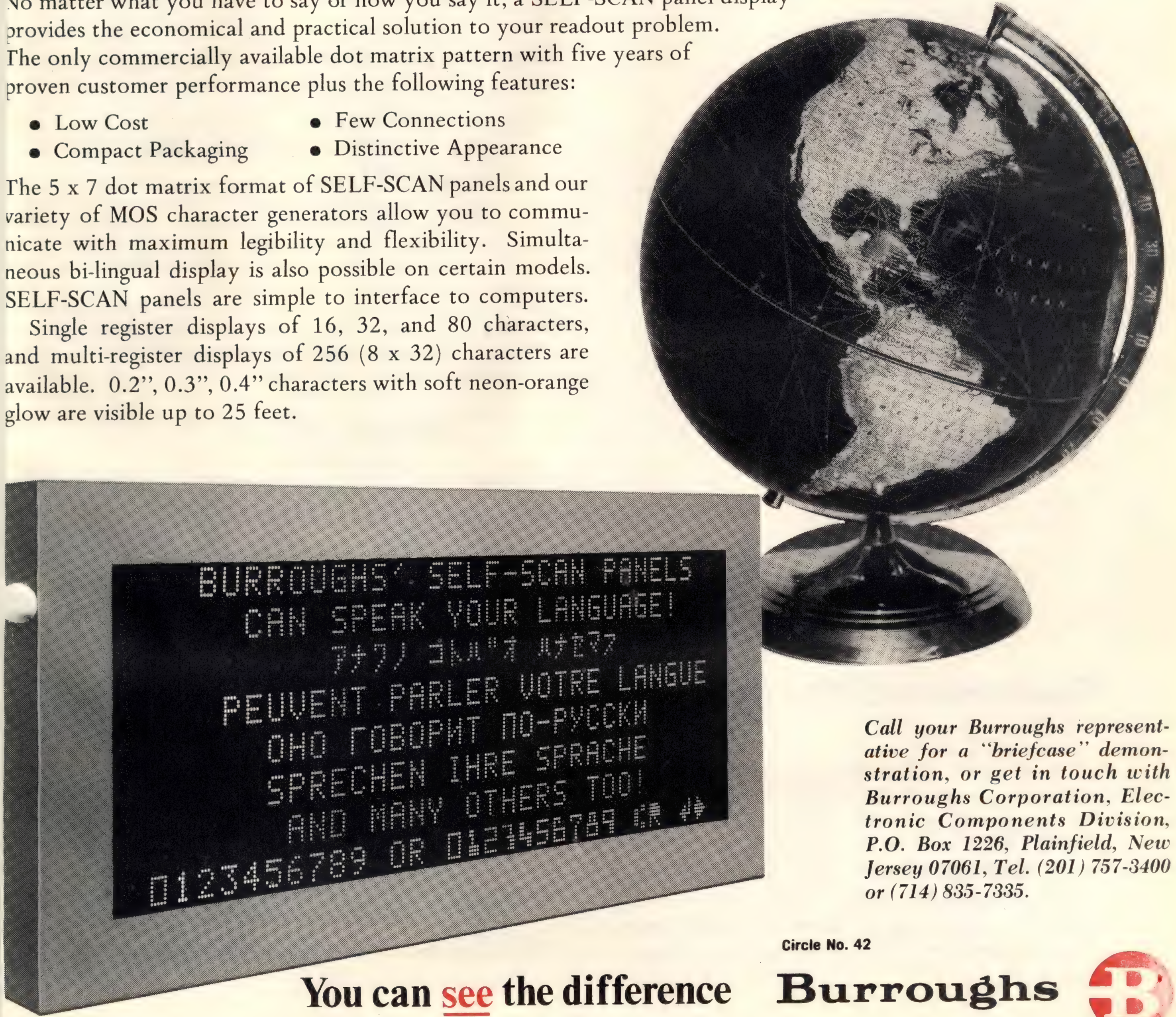

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Taking the anti-log of both sides of the equation yields:

$$\begin{aligned} \log^{-1}(y \log x) &= \log^{-1}(\log B) \\ &= B \\ &= x^y \end{aligned}$$

Therefore,

$$x^y = \log^{-1}(y \log x) \tag{3}$$

The above formula is valid for any value of x (integral or non-integral) and any value of y (integral or non-integral). If y is a negative number, simply treat it as if it is positive, then take the reciprocal of the answer.

$$x^{-y} = (x^y)^{-1}$$

For the special case where $x = e$, **Eq. 3** reduces to the following:

$$e^y = \log^{-1}(y \log e)$$

since $\log e = 0.434294$

$$e^y = \log^{-1}(0.434294y) \tag{4}$$

Example 1:

Find $\log^{-1} 2.8014$

$\log x = 2.8014$. Therefore,

$C = 2,\ m_1 = 8,\ m_2 = 0,\ m_3 = 1,\ m_4 = 4$

$$\begin{aligned} x &= \log^{-1} 2.8014 \\ &= (10^C)(10^{0.1\,m_1})(10^{0.01\,m_2})(10^{0.001\,m_3})(10^{0.0001\,m_4}) \\ &= (10^2)(10^{0.8})(10^{0.00})(10^{0.001})(10^{0.0004}) \\ &= (100)(6.309573)(1)(1.002305)(1.000921) \\ &= 632.9941 \end{aligned}$$

Actual value is 632.9946. Error = 0.00008%.

Example 2:

Find $\ln^{-1} -0.2315$ using the first four decades of the chart

$$\ln^{-1} -0.2315 = e^{-0.2315}$$

$$e^y = \log^{-1}(0.434294y)$$

Therefore,

$$\begin{aligned} e^{-0.2315} &= \log^{-1}[(0.434294)(-0.2315)] \\ &= \log^{-1}(-0.100539) \\ &= [\log^{-1}(0.100539)]^{-1} \\ &= [(1.258925)(1)(1)(1.001152)]^{-1} \\ &= [1.2603752]^{-1} \\ &= 0.7934145 \end{aligned}$$

Actual value is 0.79334270. Error = 0.009%.

Example 3:

Find 2^3 using six decades of the chart

$$x^y = \log^{-1}(y \log x)$$

$$2^3 = \log^{-1}(3 \log 2)$$

First we must find log 2, $C = 0$.

$$\frac{2}{1.995262} = 1.0023746.\ \text{Therefore,}\quad m_1 = 3$$

$$m_2 = 0$$

$$\frac{1.0023746}{1.002305} = 1.0000694 \qquad m_3 = 1$$

$$m_4 = 0$$

$$\frac{1.0000694}{1.000069} = 1.0000003 \qquad m_5 = 3$$

$$m_6 = 0$$

Therefore, $\log 2 = 0.301030$

$$\begin{aligned} 2^3 &= \log^{-1}[(3)(0.301030)] \\ &= \log^{-1}(0.903090) \\ &= (7.943282)(1)(1.006932)(1)(1.000207)(1) \\ &= 8.0000004 \end{aligned}$$

Error is 0.000005%. ☐

Reference

1. Grover H. Martin, *"Algorithm provides logs with 4-function calculator," EDN, January 20, 1974, p. 78.*

To Vote For This Circuit
Circle 162

Editor's note: This Design Award first appeared in our July 20, 1974 issue. However, errors contained therein rendered it unintelligible. Therefore, please consider this corrected version in your voting for "Best of Issue."

Fault annunciator delivers full features despite simplicity

C. E. Musser
General Electric Co., Johnson City, NY

Fault detectors are necessary in redundant and complex electronic systems to provide warning, safety, maintenance or other functional needs. This electronic mechanization fulfills five requirements:

a. It monitors at least four fault logic inputs simultaneously. (It is assumed the logic sources have been memorized.)
b. It turns on a lamp or LED if there is at least one input asserted.
c. It flashes the lamp each time an input is asserted.
d. It provides a manual capability to stop the flashing lamp in the ON state.

"Electronic signatures – a better way to *see*"

"Need a better way to predict the failure of mechanical parts such as bearings? Need to add another technique to your bag-of-tricks for analyzing problems in electronic systems? I'm Dave Luttropp, HP Product Manager for spectrum and wave analyzers. Let me show you a way."

"When you consider that most items, from devices to systems, have a unique 'signature'—a characteristic frequency spectra you can analyze for trouble-indicating changes—then you'll appreciate how signatures can give you a better way to see and solve these problems."

"Take this bearing, for example. It's worn. Sure, the engineer responsible could have waited until his screaming motor told him, but our 3580A Spectrum Analyzer gave him some early warning signs that minimized motor damage and prevented production downtime. And he didn't have to take it apart to know the bearing was worn . . . its frequency signature told him. At first, he tried to solve this problem with an oscilloscope. That didn't work because the signature was buried in noise. What he needed was a simple way to isolate the noise so the elusive signal could be clearly seen. Spectrum analysis does just that."

"There are engineers in other disciplines with this same basic need to separate noise from the signature. One wanted to analyze noise on the output of his power supply. Our HP 3580A, with its CRT display of the frequency spectrum, let him isolate harmonics and spurious noise that were sneaking through to the output. *When you need to view and identify a number of frequencies simultaneously, consider the 3580A.*"

"Of course, you don't always want to observe a frequency spectrum. Sometimes you need to measure signals or noise at specific frequencies. For example, our 3581A Wave Analyzer offered a better way for an engineer to see a ground-loop problem. Its narrow bandwidth let him home in on spurious frequencies and tackle them one at a time. *For low-level measurements at specific frequencies, the 3581A Wave Analyzer is ideal.*"

"I've seen this type of problem in so many places that I'm convinced you too could see more with one of our analyzers. They've helped solve application problems ranging from space radiation studies to researching musical-instrument overtones and harmonics. If you think 'signature analysis' can help solve your engineering problems, call me, Dave Luttropp at 303/667-5000. I'll be happy to talk electronic signatures with you. Or, call your nearest HP field engineer. He, too, can show you a better way to see and solve your problems with electronic signatures."

For New Standards in Frequency Analysis, Think HP.

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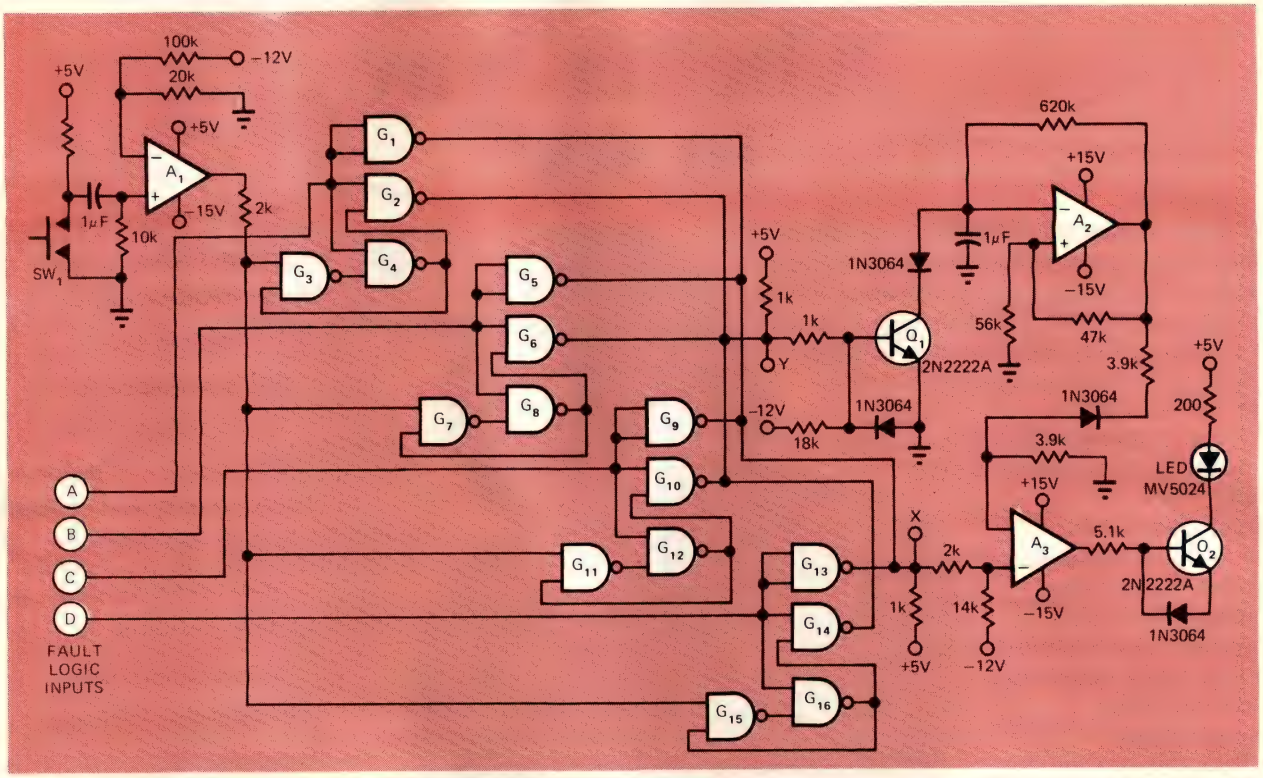
094/47

Circle No. 43



LED flashes to indicate a problem. Pressing SW_1 stops flashing, but LED remains ON until all input faults have been cleared. Inputs are expandable and latches have a fail-safe feature in the event of a loss of "memory."

e. It turns OFF the lamp if all faults are cleared.

Referring to the schematic, observe that the op amps are used as a memory loader, square wave oscillator and switching amplifier. The quad gates are used as latches and wired-OR's. Both transistors act as switches, one controlling the oscillator and the other driving the LED. The diodes protect transistor base-emitter junctions and isolate the oscillator. Two capacitors set memory loading and oscillator time constants. The resistors contribute a variety of functions from voltage divider to current limit.

To describe circuit operation, attention will be focused on input A only. All other input circuits operate identically. The description can be simplified somewhat by noting that NAND gates 1, 5, 9 and 13 are open-collector types whose outputs are connected as a wired OR (point X). Gates 2, 6, 10 and 14 are similarly connected (point Y). X is the primary control for output switching amplifier A_3. Y controls the oscillator (A_2).

When input A is LOW, all operation is quiescent. That is, the LED and oscillator are OFF and points X and Y plus A_1's output are HIGH.

However, assume now that input A is asserted. Both X and Y go to a logic ZERO (LOW). This causes A_3 to switch HIGH, turning ON Q_2 and the LED. It also turns OFF Q_1, activating A_2, the oscillator.

On the oscillator half cycle when A_2's output is LOW, A_3's output is switched LOW, turning OFF Q_2 and the LED. The next half cycle reverses the situation. The resulting flashing of the LED continues until the operator manually presses SW_1.

Pressing SW_1 switches A_1 LOW, setting the "A" latch which consists of gates 3 and 4. This action returns point Y to a HIGH state which turns ON A_1, stops the oscillator and, hence, the flashing of the LED. However the LED remains ON since point X is still LOW.

If a second failure is asserted on any other input line, point Y again returns to a LOW state, activating the oscillator and restarting the flashing action. Again, pressing SW_1 sets the latch corresponding to the particular input. Whenever a failure is cleared (input goes to its nonasserted condition), its latch is automatically reset. When the last failure is cleared the LED goes out.

Several additional features of this circuit should be pointed out. The four logic inputs are expandable so long as the memory loading feature has sufficient drive capability. Op-amp A_1 is really a 1-shot multivibrator whose time constant is adjusted to be shorter than the switch closure time. Should, for any reason, a latch lose its memory before its input failure is cleared, the lamp will flash. Finally, the square-wave oscillator incorporates a self-starting feature. ☐

To Vote For This Circuit
Circle 163

The counter specialists have done it again!

New S-D family makes buying decisions easy. 5 MHz to 512 MHz.

Whether you need a simple frequency counter, a complete universal counter-timer, or a quality communications counter, Systron-Donner has it . . . at a sensible price and with features nobody else has.

1. *Low cost* frequency counter. Model 6202A is a simple, straightforward and reliable workhorse for frequency counting to 5 MHz. Especially suited for industry and education. Price only $395.

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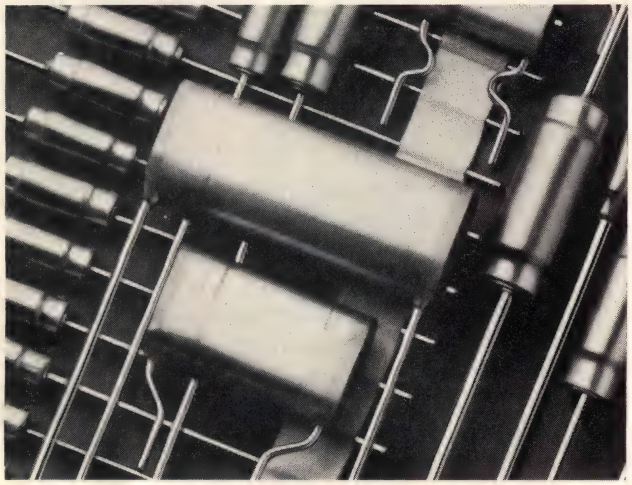
3, 4, 5. *A great communications trio.* S-D gives you a choice of three frequency counters, all with 8 digits, tone measurement and sensitivity control to reject noisy signals. Options include 5 oscillators to 5 x 10^{-10}/24 hr. and an internal battery pack. Model 6220A is a 50 MHz unit upgradable to 180 MHz or 512 MHz. Price $595. Model 6251 covers to 180 MHz. Price $895. Model 6252 (shown) measures to 512 MHz. Price $1,095. Relay overload protection and metered input are standard on the 6251 and 6252.

For immediate details contact your Scientific Devices office or Systron-Donner at 1 Systron Drive, Concord, CA 94518. Phone (415) 676-5000.

SYSTRON DONNER

Circle No. 44



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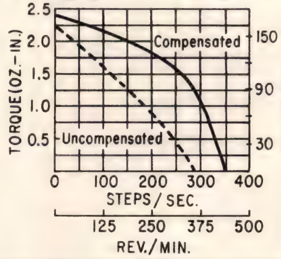

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Circle No. 46

Optically-coupled isolator features a true optical IC

PROGRESS IN SEMICONDUCTORS

Optical IC's have begun to make a commercial appearance. Without much fanfare, Hewlett-Packard started shipping earlier this year optical isolators that contain true optical integrated circuits.

Newest member in this family is a dual-channel, hermetically-sealed, optically-coupled isolator. Designated 5082-4365, the component has many features not available in other such devices. **Fig. 1** shows one channel of this isolator on a single chip. The chip includes an amplifier with feedback and a Schottky-clamped transistor output (**Fig. 2**).

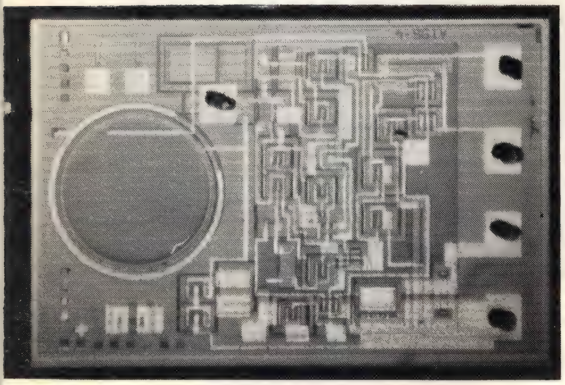


Fig. 1—Monolithic optical IC has been optimized for high speed. The large circular area is the photon detector. Two such chips are hermetically packaged in Hewlett Packard's 5082-4365.

Key features attributed to this single chip per channel approach are: (1) Operating performance guaranteed over the range of −55°C to +125°C; (2) High speed (20-Mbit operating rate); (3) TTL-compatible inputs and outputs; (4) High common mode rejection; (5) 1500V insulation voltage; (6) Hermetically-sealed DIP.

Military versions of this component are available on special order. Designated TX-4365 and TXB-4365, these units pass additional environmental and electrical testing.

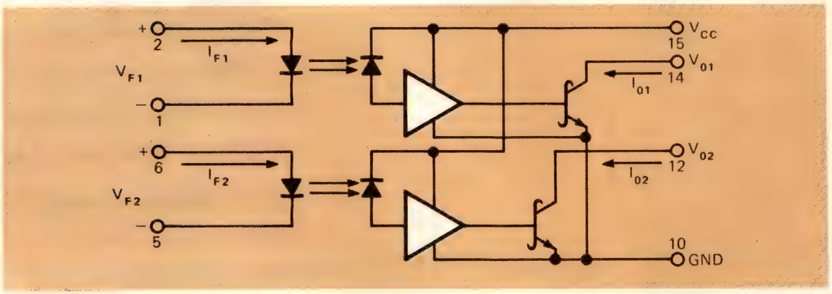


Fig. 2—Open-collector Schottky- clamped transistor output is shown in the schematic diagram of this unique OIC.

Because this opto-isolator is a true monolithic optical IC, HP's engineers could select an optimum light wavelength for high-speed operation. That wavelength is approximately 700 nm. Typical output rise and fall times are 25 nsec with propagation delay times of 90 nsec max. for both t_{PLH} and t_{PHL}.

Voltage levels are TTL compatible and fan out for each channel is six units max. Maximum input current for each channel is 20 mA.

As a typical application for these units, they are now being installed as part of the original construction of a new building. Whereas IC line receivers can work in noisy environments up to several volts, larger voltages will destroy them. However HP's optical IC's can operate in much higher noise levels such as around motors and generators without any difficulty. Other applications include logic ground isolation, computer-peripheral interfaces and high-reliability systems.

These units are available now in production quantities. The 5082-4365 is $38.50 (1-99) and $29 (100-999).

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415)493-1501.

140

Digital delay-by-events unit aids scope display of long pulse trains

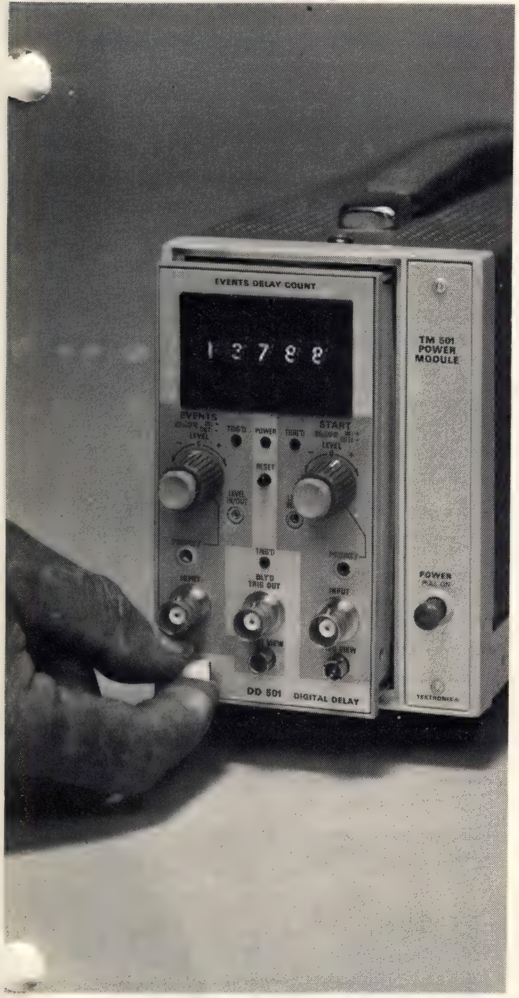
PROGRESS IN TEST EQUIPMENT

Analog (time) delay devices, when used with an oscilloscope, serve well if the desired delay can readily be specified on a time basis. However they become nearly useless if what is required is delay by a specific number of random or unequally-spaced events. It's for just that sort of delay—delay by a specific number of events—that the Tektronix Model DD 501 plug-in was developed for the modular TM 500 line. It is a digital events delay device with high-impedance (1 MΩ) signal input.

Using five thumbwheels on the control panel, the operator can set any desired digital count from 0 through 99,999. When the number of input pulses reaches the preset count, the DD 501 puts out a pulse that can be used for triggering an oscilloscope.

Jitter can't interfere

Because the DD 501 creates its delay by counting pulses rather than by analog timing of an interval, jitter is not a problem even when viewing a group of pulses toward the middle or end of a long train. Events can be counted at frequencies up to 80 MHz, and divide-by-N operation extends to 40 MHz. With the selected number of events clearly displayed on the thumbwheel dials, the operator knows at all times what part of a pulse train he is viewing on the accompanying oscilloscope. Meaningful measurements can be made on data trains up to 100,000 bits long.



The DD 501 pulse-counting delay device permits jitter-free scope viewing of recorded digital signals from flexible discs and other devices prone to speed variations.

Logic systems benefit

Delay by event is particularly useful in troubleshooting asynchronous logic systems. With these systems, it is very difficult for an observer to predict how much time will elapse prior to the pulse group he is interested in observing. The number of "clocking" events preceding the period of interest is, however, usually known and can readily be set on the thumbwheel switches.

Together with a TM 501 power module, the DD 501 forms a low-cost, portable means of providing an oscilloscope with delay-by-event capability. The input sensitivity is 85 mV p-p and the minimum detectable pulse width is 5 nsec.

Other uses abound

Almost anywhere long trains of serial data are handled, measurements can be facilitated by using the DD 501. Applications such as the viewing of selected information in data-communication pulse trains, examination of peripheral-to-central-processor data transfer, study of individual indexing pulses or data segments in disc, drum or tape memory systems can readily be handled. It is particularly applicable to rotating memory systems because the jitter caused by mechanical speed variations is eliminated.

Price is $495.

Tektronix, Inc., Box 500, Beaverton, OR 97005. Phone (503)644-0161. **141**

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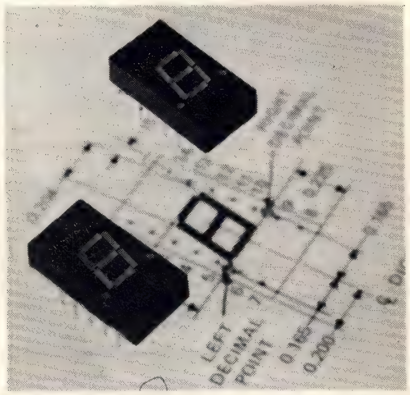
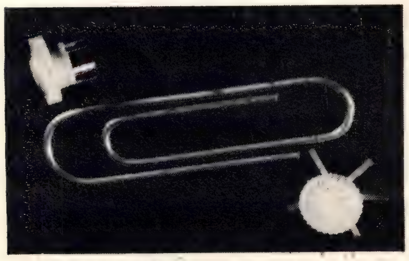
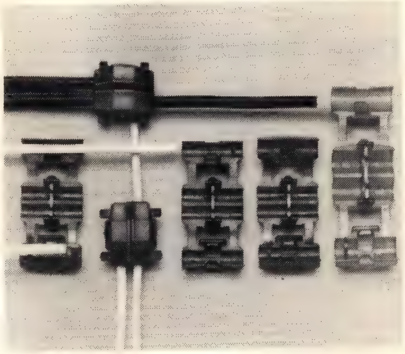


LOW-COST 0.3-IN. LED DISPLAYS PROVIDE VIEWING TO 12 FT. The TIL312 and TIL313 7-segment displays offer continuous uniform segments, high contrast and wide-angle visibility. The TIL312 is a common-anode version with right- and left-hand decimals, the TIL313 has common cathode with right-hand decimal. $3(100). Availability is 5 wks. ARO. Texas Instruments Inc., Box 5012, M/S 308, Dallas, TX 75222. Phone (214)238-2011. **188**

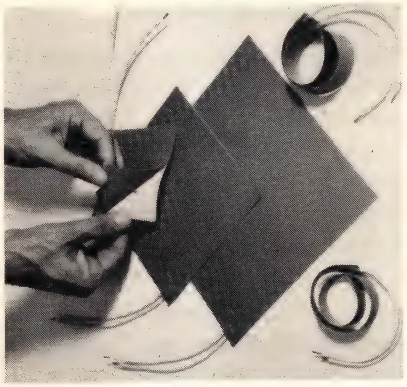
DIGITAL READOUTS EMPLOY FIELD-EFFECT LIQUID XTALS. Both reflective (Model 1650-01) and transmissive (Model 1550-01 P or N) configurations are offered in a 3-1/2 decade array. The 7-segment characters are 0.43-in. high. These displays offer significant competitive advantages, such as lower power (1/2 μW/segment at 10-15V ac, 30-1000 Hz); faster switching time (40-50 msec); higher contrast (25:1); longer life (20,000 hrs. at 12V ac); and broader operating ranges (−10 to +65°C). $21.30(100). Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. Phone(213)787-0311. **189**



MICROMINIATURE VOLUME CONTROL AND SWITCH FOR HEARING AIDS is only 11/64-in. in diameter. The CTS S-240 provides rotary switch action at the beginning of clockwise rotation. The switch is insulated from the potentiometer. Resistance values available range from 500Ω to 1 MΩ. Rating is 1/20 W at 40°C, and various tapers and knobs are offered. With switch, $3.48 (without, $2.88) in quantity. Delivery is approx. 6 wks. ARO. CTS of Asheville, Inc., Skyland, NC 28776. Phone(704)684-6451. **190**



MINIATURE CONNECTOR GRIPS, STRIPS, AND INSULATES. Applied with a single closure of ordinary hand pliers, the Electro-Tap connector eliminates conventional wire-stripping and insulating steps when tapping into solid or stranded wire sizes AWG #14 to #18. Tin-plated brass contacts form connections, while 2 hinged insulating (nylon) wire supports make tapping fast and easy. AMP Inc., Harrisburg, PA 17105. Phone(717)564-0101. **191**



STICK-ON RESISTANCE HEATERS COME IN SQUARES AND RIBBONS. Instant heating 115V "Stik-on Heaters" are paper-thin. The heat is uniform over the entire surface, due to their foil construction. Stock sizes include 2-, 4-, 6-, 8- and 10-in. squares and 1- and 2-in. ribbons, 6- to 36-in. long. All are insulated with fiberglass-impregnated silicone rubber and are backed with an adhesive capable of withstanding 350°F. Sierracin/Thermal Systems, 13920 S. Broadway, Los Angeles, CA 90061. Phone(213)321-4350. **192**

1/8W CARBON-FILM RESISTORS HAVE LOW TC OF RESISTANCE. Mechanically interchangeable with all composition and most metal-oxide resistors of the same power rating, the CF-1/8 features a resistance range at ±5% of 2.2Ω to 220 kΩ, max. working voltage of 250V, and an operating temperature range of −25 to +125°C. Max. voltage coefficient is −0.01%/V. A superior coating aids long-term stability and offers flame retardance. Airco Speer Electronics, Bradford, PA 16701. Phone(814)362-5536. **193**

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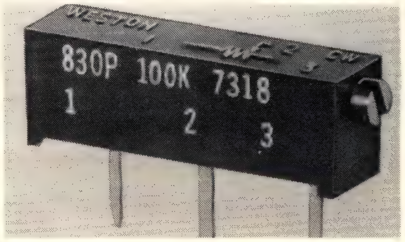

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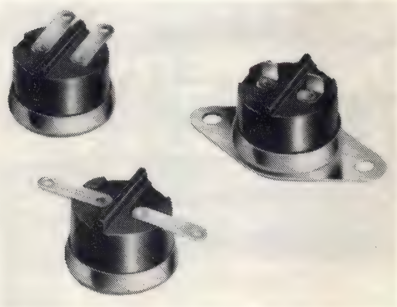

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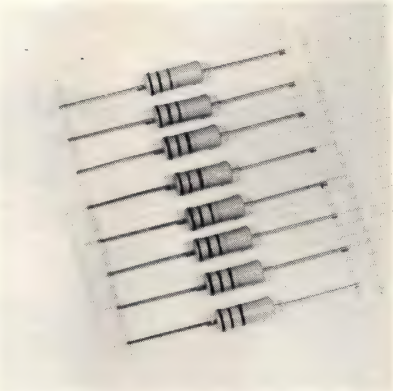
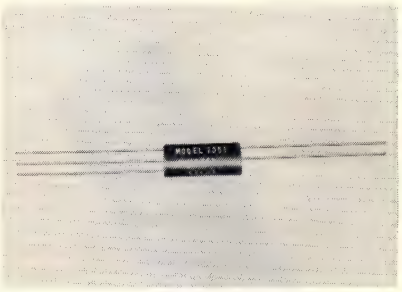
OPTICALLY-COUPLED ISOLATOR FEATURES 15 kV ISOLATION. OPI 120 consists of an npn silicon planar phototransistor coupled with a high-efficiency GaAs I.R. emitter and mounted in a high-voltage plastic package. Both the phototransistor and LED are housed in hermetically-sealed TO-18 type configurations. Typical current-transfer ratio is 50% with an input of 10 mA. $7.50(100). Optron, Inc., 1201 Tappan Circle, Carrollton, TX 75006. Phone(214)242-6571. **197**



METAL GLAZE FILM NETS LOW NOISE IN H.V. RESISTORS. Series VR film resistors provide noise characteristics of 0.5 µV/V in resistor values of 1 to 68 MΩ. Resistance tolerance is ±5% and the TC of resistance is ±200 ppm/°C. Voltage limits are 2.5 and 7 kV for 1/2 and 1W styles, respectively. A light blue conformal coating provides protection and aids identification. Mepco/Electra, Inc., Columbia Rd., Morristown, NJ 07960. Phone(201)539-2000. **198**



LONG-LIFE REED RELAY CLAIMS TO BE SMALLEST AVAILABLE. Claims for the Model 7001 include 3V, 60 mW drive power, fast switching and 10-million cycle life. It is a spdt solidly-encapsulated unit with switching speed of 0.5 to 2 msec. Size is 3/4-in.L×1/4-in.D. $9.50(100). Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. Phone(213)785-4473. **199**

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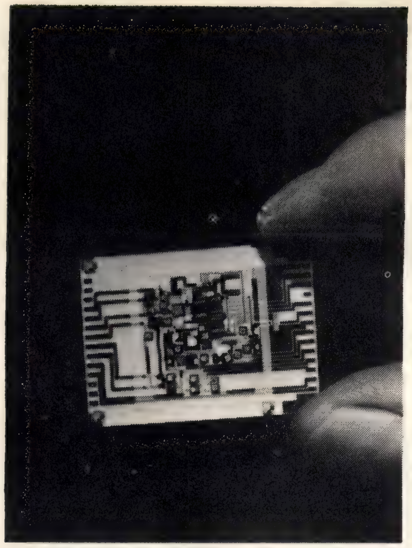
Circle No. 52



THICK-FILM MULTILAYER DIELECTRIC YIELDS HIGH RESOLUTION. EMCA 3186B is a low-K crystallizable thick-film dielectric for multilayer high-density circuits. Firing temperature is 850 to 1000°C for 10 to 15 min. at peak temperature. When double printed, using a 325-mesh screen, fired thicknesses between 1.1 and 1.4 mils are obtained. For precision registration a blue, organic dye is included that fires out, leaving an opaque creamy-white film. $25/oz. in quantity. Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, NY 10543. Phone(914)698-8434. **200**

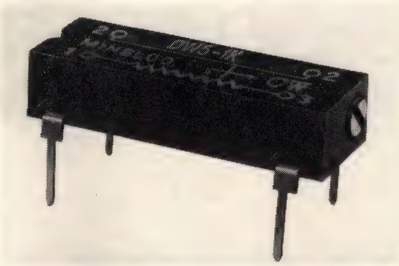
CRYSTAL-CLEAR EPOXY RUBBER PROVIDES SUPERIOR EMBEDMENT. MERECO 4501, an epoxy-resin system that contains no solvents, cures into a transparent rubber-like gel. The cured material is tough, yet firm and flexible. Its low viscosity (approx. 750 cps), coupled with a long working life at room temperature, allows easy air-bubble release and mixing. Electrical specs include 450V/mil, dielectric constant of 3 and dissipation factor 0.02. Mereco Products, 530 Wellington Ave., Cranston, RI 02910. Phone(401)781-4070. **201**

ENCAPSULATED LED INDICATORS SNAP-MOUNT INTO PANEL FRONT. N503 indicators use GaP LED's with light output (red or green) of 3 mcd @ 20 mA. Models are offered for forward voltages of 5-6, 12-14, 18 or 28V. Color-coded 6-in. insulated leads speed assembly. Sorenson Lighted Controls, 530 Oakwood Ave., West Hartford, CT 06110. Phone(203)236-3267. **202**

ROCKER DIP SWITCHES PROVIDE 50,000-OPERATION LIFE. Series 76 rocker DIP units have from 2 to 10 independent spdt switches. They feature easy mounting to a pc board by direct flow soldering or insertion into a standard socket. Above-board height is 0.305 in. Make and break rating is 35,000 operations at 50 mA @ 30V dc. From $2.65 for a 2-position switch and $4.30 for a 10-position switch. Grayhill, Inc., 561 Hillgrove Ave., La Grange, IL 60525. Phone(312)354-1040. **203**

VACUUM PICK-UP TOOL OPERATES FROM SHOP AIR. Vac-Pic lets you pick up, hold and handle small parts, components and hard-to-handle items. It is air operated and needs no auxiliary vacuum pump. Air use is as little as 1/10 Sft^3/min. at 25 psi. It is held like a pencil and the operator's index finger controls the vacuum. Bay Vacuum, Inc., 440 Convention Way, Redwood City, CA 94063. **204**

ALUMINUM SUBASSEMBLY HOUSINGS ACCEPT 0.062-IN. PC BOARDS. SH series comprises off-the-shelf kits and parts for "black box" subassembly housings. They assemble with tongue-and-groove interlock. Overall dimensions range from 2×3×4 to 8×8×4 in. Kit prices range from $7.74 to $27.63. Techmar Corp., 2232 S. Cotner Ave. Los Angeles, CA 90064. Phone(213)478-0046. **205**



WIREWOUND DIP TRIMMER RESISTS CLEANING SOLVENTS. Model DW5 is available in single or multiple loading magazines for manual or automatic insertion. Resistance values from 10Ω to 50 kΩ are offered. The T.C. of resistance is <50 ppm/°C between −55 and +125°C. The trimmers are designed with a stand-off for efficient board cleaning and their pc pins are gold plated. Minelco Div. of General Time, 135 S. Main St., Thomaston, CT 06787. Phone(203)283-8261. **206**

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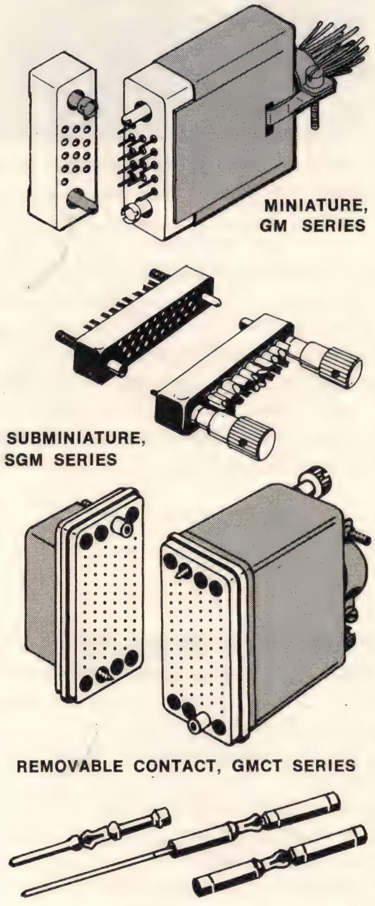

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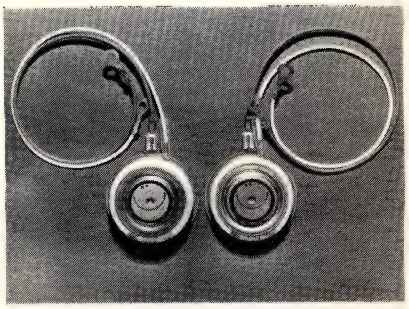
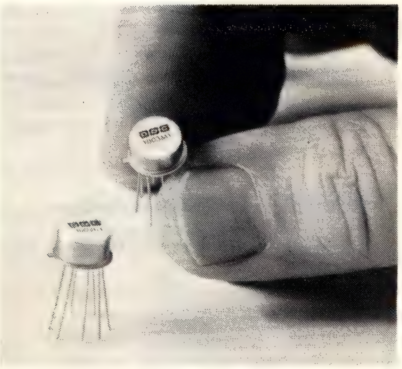
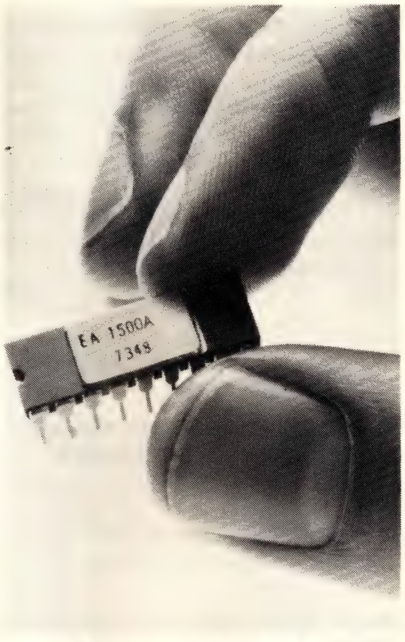


SMILE IS OPTIONAL ON DISC SCR'S. Ideal for phase and inverter motor controls these SCR's offer 250A average current with 600-1600 voltage rating. CS 250 phase control and CS 259 inverter are packaged in MU 31A pressure cans. Both devices have max. peak, 1-cycle surge-current rating of 8000A. In 600V, CS 250 is priced at $24.40 (100) and CS 259 $64.40 (100). Brown Boveri Corp., 1460 Livingston Ave., North Brunswick, NJ 08902. Phone(201)932-6066. **207**

PRODUCTION IMPATT DIODES COST LESS. Two pulsed silicon Impatt diodes and 2 CW power sources feature generally higher power than the developmental devices from which they were derived. X-band pulse unit (5082-0710) has a peak power of 12W at 10 GHz. There are 2 X-band CW units; 5082-0610 provides 1.5W min. at 11.2 GHz; 5082-0611, 2.5W at 11.2 GHz. Ku-band 5082-0716 has 10W peak at 16 GHz. Efficiency of these units is typ. 10%. All meet MIL-S-19500. $110 to $181 (25-49). Hewlett Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501. **208**

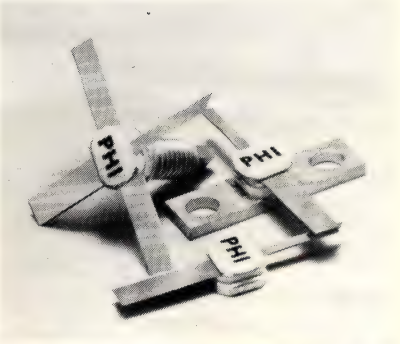


MONOLITHIC LOW-POWER OP AMP IS PIN-COMPATIBLE WITH 741. The amplifier is specifically designed for very low standby power consumption over a wide range of supply voltages. Other features are low input current, noise and offset. Packaging is in a TO-99 can or mini DIP. Pricing is $2-$15 depending upon package and temperature range. ILC Data Device Corp., Airport International Plaza, Bohemia, NY 11716. Phone(516)567-5600. **209**



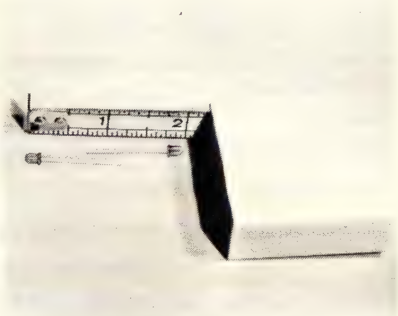
NMOS RAM FEATURES 60 nSEC ACCESS. This 1024-bit RAM is fully decoded or can be OR-wired to expand capacity. ±15V power supplies are required. A simple refresh technique makes the dynamic device as easy to operate as a static RAM. One pulse on a pin refreshes the entire memory. Price, 18-pin DIP, is $13 (500). Electronic Arrays Inc., 550 E. Middlefield Rd., Mt. View, CA 94043. Phone(415)964-4321. **210**

RECIRCULATING DYNAMIC SHIFT REGISTER OFFERS HIGH SPEED. The NEC 2512 shift register includes on-chip internal recirculation logic, built-in read-write control and 2 chip-select controls for ×4 matrix selection. This unit can replace delay lines on small drum memories. Available in either, 10-lead TO-100 metal package or 8-pin molded mini-DIP, power consumption is 100 μW/bit. Pricing is $46.60, for the 10-pin version (100-999). Nortec Electronics Corp., 3697 Tahoe Way, Santa Clara, CA 95051. Phone(408)732-2204. **211**

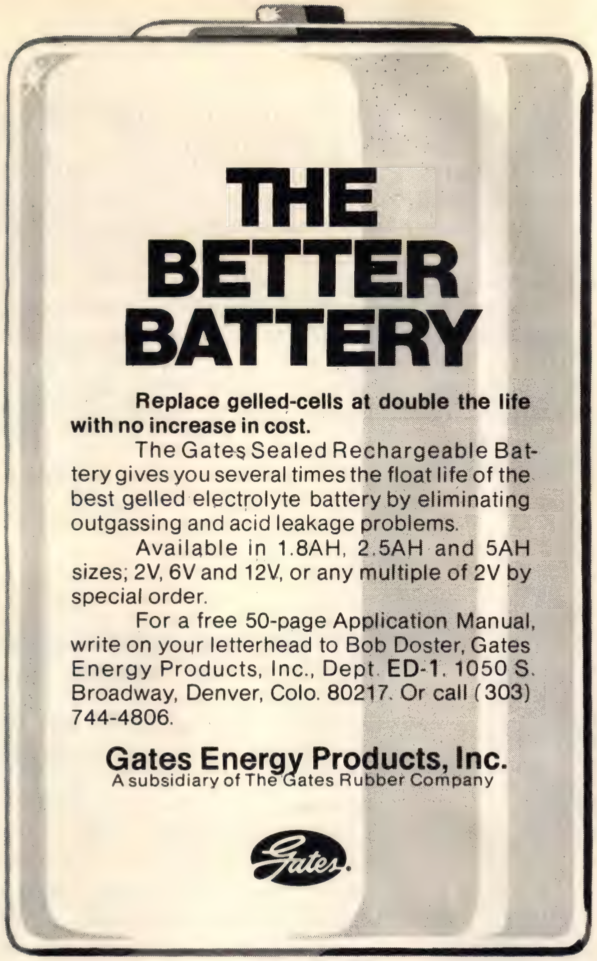


3-GHz TRANSISTORS FEATURE LOW COST. All units are gold metalized and emitter ballasted. Included are 6, 4 and 1W versions housed in hermetic ceramic-to-metal, flange, stud or pill packages. At 3 GHz these units produce 6W of RF power with 5.2 dB of gain. Efficiency is 33% at 28V. Pricing is $95 for the 6W units. Power Hybrids Inc., 7281 Garden Grove Blvd., Garden Grove, CA 92641. Phone(714)892-4334. **212**

FIRST-IN FIRST-OUT MOS MEMORIES. This line of FIFO's offers max. ripple-through time of 8 μsec. The AM 2813ADM is organized into 32×9 bits and has parallel inputs and outputs. AM2812ADM is 32×8 bits and features serial and parallel inputs and outputs. Both units are available in 500-kHz versions. Price (−55 to 125°C) is $28 (100-up). Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, CA 94086. Phone(408)732-2400. **213**



MINIATURE RED LED OFFERS WIDE VIEWING ANGLE. Model 521-9189, a GaAsP lamp with peak emission at 6500 Å, provides *luminous intensity* of 0.5 mcd. Continuous forward current rating (25°C or below) is 40 mA. 15¢(1000). Dialight Corp., 203 Harrison Pl., Brooklyn, NY 11237. Phone(213)497-7600. **214**



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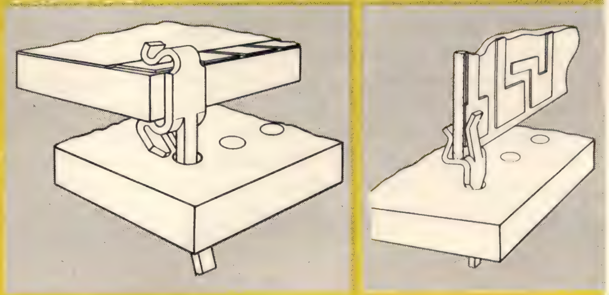

These Ceramic Substrate Connectors clip-in-place on the substrate and mechanically hold their position until wave soldered for a permanent connection. No drilling is required. DIP-CLIP type mounts onto DIP packs; EDGE-CLIP is designed for edge mounting. Available in brass, phosphor bronze or steel. Supplied in strip form for manual operations or for Berg high-speed application machines which assure higher assembly rates while lowering applied costs. Berg also offers fast turn around in designing special connectors and application tools for large-volume applications. Write for Catalog 124, or call:

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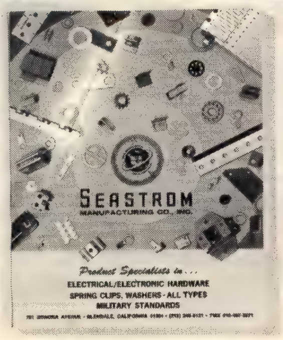
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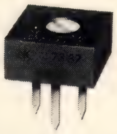

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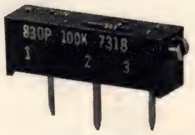

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Circle No. 58

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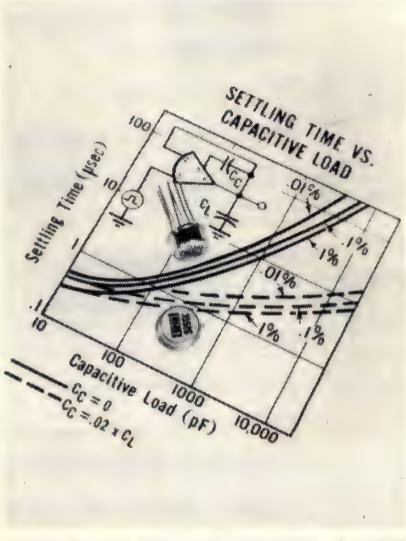
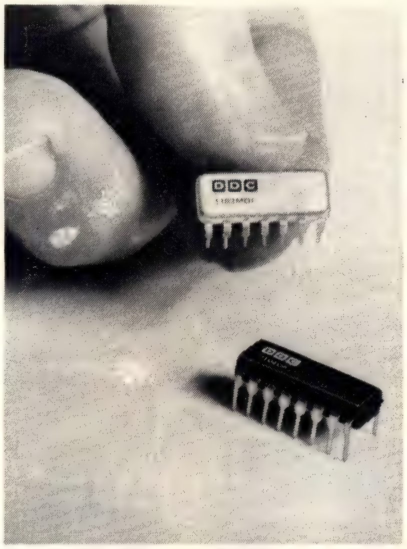
MOS/ROM REQUIRES NO CLOCK UNIT. A new 16k MOS/ROM operating statically with an access time of 950 μsec requires no external address decoding. These circuits are already on the chip and consequently need no pull-up resistors for TTL logic. The EA 4900 is packaged in a 24-pin ceramic or silicone-molded DIP. $28 (100). Electronic Arrays, Inc., 550 E. Middlefield Rd., Mt. View, CA 94043. Phone(415)964-4321. **215**

TRANSISTORS OFFER 65A CAPABILITY. This series, available in TO-68 packages, can operate at 80V peak. These devices have applications in computer peripherals, communications equipment, inverters and converters, audio amplifiers and battery-operated equipment. Prices range from $4-$19 according to quantities. Germanium Power Devices Corp., Box 65, Shawsheen Village Station, Andover, MA 01810. **216**



WIDE-BAND OP AMP OFFERS QUICK SETTLING. This FET IC op amp provides max. settling time to 0.01% of 600 nsec, a 20-MHz bandwidth at unity gain and a slew rate of 100V/μsec. The 3550 K offers the same slew rate when operated as an inverter or noninverter. Typical dc open-loop gain is 100 dB and input impedance is $10^{11}\Omega$. Small quantities, $18. Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. Phone(602)294-1431. **217**

FOUR NEW IC'S JOIN SCHOTTKY LINE. These high-speed TTL circuits in 16-pin DIP's were developed for computer-based instrumentation. The N74S86 quad exclusive-OR offers 7 nsec delay time. $1.94 (100). N74S133, a 13-input NAND gate, features 6 nsec propagation time. 54¢ (100). N74S134 is a 12-input NAND gate providing bussing capabilities and tri-state outputs for wired OR's. N74S138 is a 3- to 8-line decoder/demultiplexer. $4.86 (100). Signetics, 311 E. Arques Ave., Sunnyvale, CA 94086. Phone(408)739-7700. **INQUIRE DIRECT.**

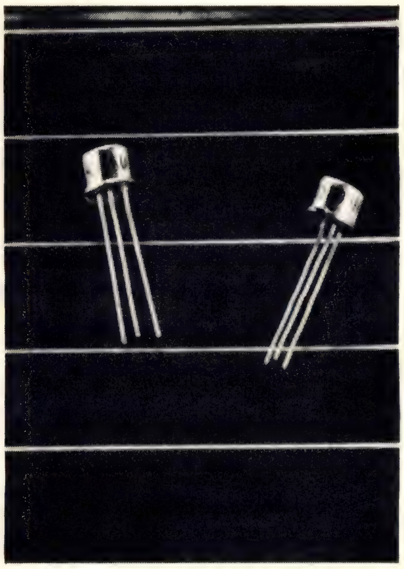


FET ANALOG SWITCHES CUT COSTS. Designated DDC 1101-1108, each package contains up to 4 channels of analog switches. The need for an external driver is eliminated. The 1101-1104 devices, driven directly from low-level TTL logic, multiplex and commutate into a virtual ground of an op amp. 1105-1108 devices consist of floating switches and are capable of switching 0 to +20V dc signals. The ON channel resistance for the entire series is < 150Ω. In moderate quantities the price is $1. ILC Data Device Corp., Airport International Plaza, Bohemia, NY 11716. Phone(516)567-5600. **218**

PLASTIC VERSIONS OF 3 ISOPLANAR RAM'S INTRODUCED. The first 1024-bit bipolar memory introduced is now available in plastic. Pricing is $22 in 100-piece quantities. 256×1-bit memories with open collector output and 3-state output are priced at $12.40 in 100-piece quantities. Fairchild Camera & Instrument Corp., 464 Ellis St., Mt. View, CA 94040. Phone(415)962-5011. **219**

ERROR DETECTION-CORRECTION CIRCUITS INTRODUCED. These IC's generate modified hamming SEC-DED codes to correct erroneous bits in storage or data transfer. The MC10163 is specifically designed for error correction of the SEC-DED code used in IBM 370/145 memory. Packaged in a 16-pin ceramic DIP, these units are rated for −30 to 85°C operation. Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. Phone(602)244-6900. **220**

GaAs VARACTOR DIODES PROVIDE Q'S FROM 2400 TO 5000. These gallium-arsenide varactor diodes offer capacitance ratios up to 6:2. Multiple-lead internal construction minimizes series inductance. Total capacitance values may be specified from 0.5 pf to 5 pf with ±10% tolerance. Price in small quantities is $75 each. Varian, Solid State West Div., 611 Hansen Way, Palo Alto, CA 94303. Phone(415)493-4000. **221**



VOLTAGE REF. FEATURES STABILITY OF 40 PPM/°C, 25 μV/MO. This low-current device offers advantages over a zener diode. Quiescent current is 1.5 mA max.; turn-on time is 6 μsec. The AD580, a 3-terminal device, provides a 2.5V ±2% output for inputs between 4.5 and 30V. $2 (100). Analog Devices Inc., Box 200, Rte. 1 Industrial Park, Norwood, MA 02062. Phone(617)329-4700. **222**

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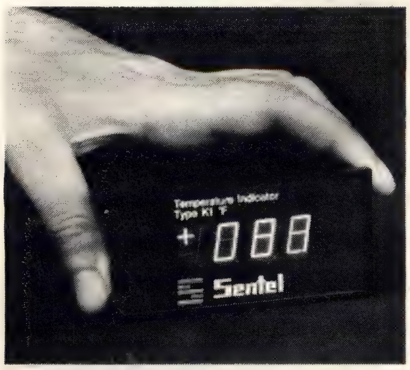
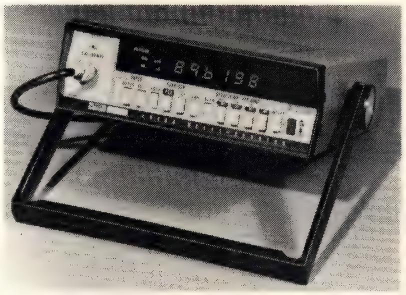
CONVERTER/CALCULATOR HANDLES 112 DIRECT CONVERSIONS. The Rockwell 203 is a pre-programmed universal converter that handles US, metric and imperial constants. It converts length, volume, area, temperature or weight. There are 2 fully-addressable memories, so that 203 can be used in calculating basic arithmetic functions, chain calculations and calculations with fractions and decimal numbers. Price, including batteries and ac charger, is < $140. Rockwell International, 950 DeGuigne Dr., Sunnyvale, CA 94086. Phone(408)735-7000. **224**

DMM/COUNTER OPERATES ON BATTERIES. Model 4440 measures ac and dc volts, ac and dc current and resistance —and counts frequency to 10 MHz. It will operate for approx. 6 mo. from disposable alkaline batteries (ac line operation and rechargeable batteries are optional). Accuracy is 0.05% on dc volts and 0.01% on count. $299. Valhalla Scientific, Inc., 7707 Convoy Ct., San Diego, CA 92111. Phone(714)277-2732. **225**



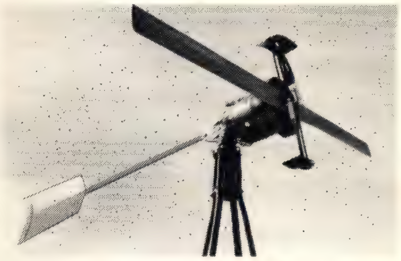
DIGITAL TEMPERATURE INDICATOR FITS STANDARD DIN CUTOUT. Model 200, designed to replace analog indicators in the OEM and process-control industries, operates in either °F or °C with J-, K- and T-type thermocouples. Featured are 1° resolution, 3-1/2 digit bipolar Beckman display, automatic cold-junction reference and a thermocouple break detector. $195. Sentel Corp., 4015 Fabian Way, Palo Alto, CA 94303. Phone(415)324-1761. **226**

SWEEP/FUNCTION GENERATOR CLAIMS $150 PRICE EDGE. Model 196 generates sine, square, triangle, ramp, pulse and swept waveforms as well as a ramp sync output and a separate TTL pulse output. Frequency range is 0.1 Hz to 1 MHz, with 20V p-p output. The internal sweep generator provides 1000:1 sweep width at rates from 1 msec to 10 sec. Typical sine distortion is < 0.5%. There is a voltage-controlled frequency (VCF) input. $350. Exact Electronics, Inc., Box 160, Hillsboro, OR 97123. Phone(503)648-6661. **227**



AUTORANGING MULTIFUNCTION COUNTER FEATURES AUTORESET. The 80-MHz Model 1900A with advanced MOS/LSI circuitry has autoreset on all functions, gate times, filter and attenuator. Its autoranging is effective in both frequency and period measurement modes but 4 over-riding gate times permit manual selection of resolution to 0.1 Hz. The 1900A can totalize, measure frequency and period, and count events up to 10^6. Sensitivity is 25 mV. $349. John Fluke Mfg. Co., Ltd., Box 1094, Station D, Buffalo, NY 14210. Phone(716)842-0311. **228**

CALCULATOR-BASED SYSTEM LOGS, COMPARES AND ANALYZES DATA. The 31/53 has many minicomputer capabilities, but doesn't require knowledge of a computer language to operate. It combines the concept of a stand-alone data recorder and data analysis computation. The system includes the Tektronix 31 calculator, a mainframe power source, an interface plug-in, standard software for data acquisition and analysis, and standard options and accessories. $3995. Tektronix, Inc., Box 500, Beaverton, OR 97005. Phone(503)644-0161. **229**



12V WIND-POWERED GENERATOR CHARGES WITH 7-MPH WINDS. The No. 19,189's 6-ft propeller, built on the Albers Air-Foil principle, turns a 200W generator with fully-sealed grease bearings. An air-brake governor automatically prevents overcharging. The enclosed collector ring with double carbon brushes protects against dust, frost and ice. The 4-leg angle iron tower is 10 ft high. $475 postpaid, including instrument panel but without 12V battery. Edmund Scientific Co., 380 Edscorp Bldg., Barrington, NJ 08007. Phone(609)547-3488. **230**

2-CHANNEL, 200 MHz SCOPE HANDLES COMPUTER SERVICING. Model 1710B, with deflection factors to 5 mV/cm, sweep speeds to 1 nsec/cm and frequency response to 200 MHz, is well-suited for servicing computers that use ECL 10K or Schottky TTL logic. Its tight accuracy, delayed sweep and stable triggering all add to the capability—and the price of $2625 makes it affordable. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501. **231**

12-IN. X-Y DISPLAY SCOPE SUITS PRODUCTION TEST NEEDS. Model 1901A has an extremely stable, low-noise vertical amplifier with sensitivities from 1 mV/div. and a 15-kHz vertical B.W. The 9-kV accelerating potential provides a bright, narrow trace. There are separate intensity controls for the beam and an intensity marker. Protection circuits automatically blank off the trace in the event of no horizontal input. $475. Wavetek, Indiana Inc., 66 N. 1st Ave., Beech Grove, IN 46107. Phone(317)783-3221. **232**

The standard voltage/current generator is programmable and employs a calibration-free, pulse-width modulation method.

• RANGE: OUTPUT VOLTAGE 1μV-1199.999V; OUTPUT CURRENT 1mA-119.9999mA • ACCURACY: ±0.001% (DCV), ±0.004% (DCA) TRACEABLE TO THE NATIONAL STANDARD • STABILITY: ±0.0005%-OF-SETTING A DAY • PROGRAMMABLE BY 14 BUILT-IN MEMORIES, MANUAL AND EXTERNAL • EXTERNALLY CONTROLLABLE • CONTINUOUSLY VARIABLE OUTPUT SETTING

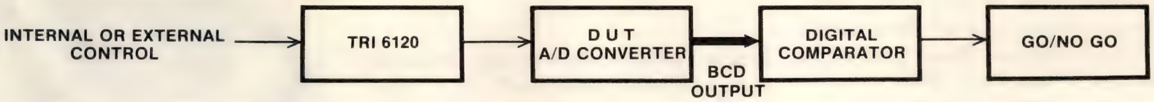
The 6120 is a standard voltage/current generator which employs a unique pulse-width modulation method (wherein the reference voltage is divided by pulse trains made by the logic circuits). Because of the pulse-width modulation method, the stability of the output is excellent and calibration-free.

The 6120 has 14 built-in memories into which output, limit level, polarity and range can be programmed. The programmed output can be taken out in either random, step, single-scan, or repeat-scan modes.

The 6120 is remotely controllable for systems application. The unique feature of the generator is it's continuously variable 3 digits. Output setting of any 3 continuous digits can be continuously varied by one control switch. This is convenient in setting continuously varying output.

Thanks to these features, the 6120 has a wide range of application which includes application to an automatic test of components, and instruments such as variable capacitors, diodes, transistors, A/D converters, meters, PC boards, amplifiers and many others.

Illustrated below is one of the application examples.



Programmed outputs in the 14 channels are fed into the input of the A/D converter in a desired scanning mode. The output of the BCD is then compared by the digital comparator. Compared linearity of the A/D converter is thus easily tested.

For further information and a demonstration, please call or write T.R.I. Corp.

TRI

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Circle No. 60

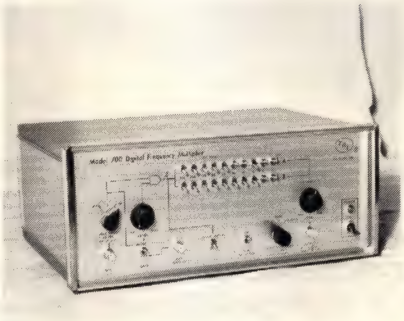
4-1/2 DIGIT DMM COMBINES LOW PRICE, LONG-TERM STABILITY. Thanks to the use of precision wirewound resistors and socketed IC's, Model 4140 will operate over long periods and wide temperature extremes without a reduction of accuracy. It also needs fewer calibrations than most multimeters. A Beckman display insures ease of reading. $495. Berkeley Instruments, Inc., 1701 Reynolds, Santa Ana, CA 92705. Phone(800)854-3253. **233**

PROCESS MONITORING SYSTEM EMPLOYS MICROPROCESSOR. A DDAS, the Autodata Eight, comprises a ready-to-operate, 40-channel system that is expandable to 1000 channels. Priced at $4950, it is suited for monitor, alarm and control applications. Available options and peripherals include 7- or 9-track magnetic tape, tape cassette, punched paper tape, keyboard/CRT units, data modems and high-speed printers, digital inputs, alarm and control panels. Vidar Autodata Inc., 265 N. Whisman Rd., Mt. View, CA 94040. Phone(415)965-3050. **234**

COORDINATOGRAPH SPEEDS UP PROCESSING ON PC ARTWORK. Draftek Model 1210's tungsten-carbide scribing blades in rack and pinion controlled tools produce intricate, one-to-one designs with dimensional accuracy of ±0.002-in. Photo-processing delays are eliminated. Thin, closely-spaced circuit paths, for example 0.15-in. wide paths on 0.01-in. spacing, can be laid down consistently. $1800. Mexel, Inc., Box 599, Lebanon, NJ 08833. Phone(201)534-2000. **235**

REMOTE CONTROL IS STANDARD ON MULTIFUNCTION COUNTER. On the OEM Model 2319FE all functions are remotely or locally controlled by noncritical TTL/DTL signals. Capabilities include time-interval measurements of pulse width, period, B-A (to 100-nsec resolution), frequency (0.1- , 1- , 10-sec time base), events period B, events B-A and frequency ratio E/B. Price with 0.0025% time-base accuracy, $725. Modular Devices, Inc., 1385 Lakeland Ave., Bohemia, NY 11716. Phone(516)567-9620. **236**

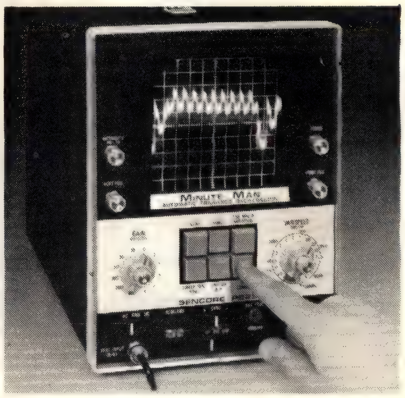
POWER-LINE SURGE PROTECTOR HANDLES 15A AT 115V. The Model 425 attaches to a standard convenience outlet (gem-box type) and accepts 3-prong line-cord plugs. It provides 3-step protection—gas tube, circuit breaker and fuse (the first 2 are self restoring). $24.95. Telecommunications Industries, Inc., 1375 Akron St., Copiague, NY 11726. Phone(516)842-5000. **237**



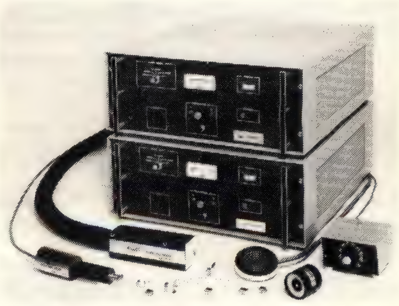
DIGITAL FREQUENCY MULTIPLIER ACCEPTS ALL INPUT WAVESHAPES. Model 700 multiplies the frequency of an input signal by the ratio A/B, where both A and B can be preset to any integer from 1 to 1023 by front panel switches. The input audio-frequency waveshape can be sine, triangle, square or complex. The output is a square wave with 50% duty cycle. $769. TDL of Las Cruces, P.O. Drawer H, Las Cruces, NM 88001. Phone(515)382-5574. **238**

OPEN-FRAME SWITCHING POWER SUPPLIES HAVE 2-YR WARRANTY. Type SRS/SRX supplies employ computer-grade electrolytics, plug-in IC regulator and conservative ratings. Models are available that provide 5V at currents from 3 to 15A (12, 15 and 24V models, too). Pricing runs from $40 up. NJE Corp., Box 50, Culver Rd., Dayton, NJ 08810. Phone(201)329-4611. **239**

OEM MINIATURE PRINT MECHANISM HANDLES 15 COLUMNS @ 3L/SEC. The 2090 Microprinter has a single print hammer for each 3 print columns, so only 5 hammers and actuators are needed for the standard 15-column model. An ac motor speeds start/stop operation. The printer uses a disposable, snap-in ribbon cartridge with a 2-color ribbon. Size is 5.4×5.2×2.3-in. and delivery is 90 days ARO. Mohawk Data Sciences Corp., Box 362, Utica, NY 13503. Phone(315)792-2202. **240**



PUSHBUTTONS CONTROL DISPLAYS ON AUTOMATIC-TRIGGERED SCOPE. The PS 29's pushbutton displays include TV vertical, TV horizontal, 3.58 MHz for viewing the color subcarrier information, 5× expand and a completely front end vector display. The sixth button sets the scope for 60-Hz line sweep. Other features include dc coupling, 5000V ac input protection, 10-MHz bandwidth and 10-mV sensitivity. $495, probe included. Sencore, Inc., 3200 Sencore Dr., Sioux Falls, SD 57107. Phone(615)339-0100. **241**



−65/+200°C WITHOUT AN ENVIRONMENTAL CHAMBER. The Model TP27 Super ThermoSpot^{R} has 2 independent temperature-controlled heads that can bring a 40-lead hybrid or LSI to −55°C or +125°C within 45 sec, and to −65°C or +175°C within 90 sec. Its accuracy is ±1°C and stability is ±0.3°C. Narrow-band proportional dc control is used. Delivery: 6-10 wks. ARO. Temptronic Corp., 40 Glen Ave., Newton, MA 02159 Phone(617)965-3420. **242**

Move up in performance, or down in price.

If you've been sacrificing oscilloscope specs for price, now you can move up in performance. Or, if you're used to high performance, you can keep it and pay less. Because HP's new 1720A has the specs you want at just $3,400.* In fact, for less than the price of its nearest competitor, you can get the 1720A and still have money left over to buy an HP model 45 calculator, and a 970A probe digital multimeter.

This scope's 275 MHz bandwidth spec holds over the entire viewing area . . . on all deflection ranges . . . in both input impedance modes . . . whether the amplitude vernier is used or not . . . from 0 to 55°C.

Stable triggering lets you change position, vernier, and polarity controls without losing sync. It triggers on low-level signals, yet refuses to double trigger on noise. And it triggers well beyond its bandwidth – often to 400 MHz or above.

Fast linear sweeps and a wide 10 cm screen give you high resolution for accurate high-speed digital timing measurements. Flood guns provide a display that's easy to view and photograph. And the logical layout of color-coded controls make this new high-speed scope a pleasure to operate.

Custom ICs and improved packaging provide a new dimension of simplicity in calibration and servicing (internal adjustments have been cut about in half compared to other scopes in its class). And a lower component count means higher reliability – over 3,500 hours MTBF.

Any way you look at it – comparing features, or figuring cost of ownership – the 1720A gives you exceptional scope value. So move up in performance . . . or down in price, with HP's high-performance 1720A. Just contact your local HP field engineer. He'll also give you details on our new 200 MHz 1710B, at just $2,625,* for field-service applications.

*Domestic USA prices only. 084/8

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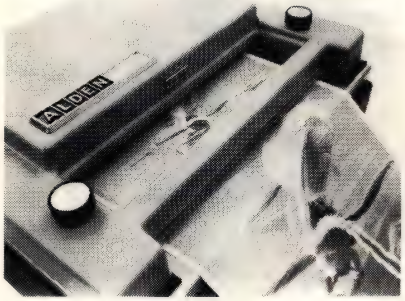
Circle No. 61

LOW-COST CASSETTE SYSTEM IS BUILT FOR MINI'S. Sykes tape model 80 is a low-cost, high performance, sequential cassette system. It includes off-the-shelf interfaces and software drivers for most minicomputers: DEC, Data General, DCC equivalent, Varian, HP, Micro and CIP. The system features a speed of 9600 bps, rewind at 120 ips and capacity of > 30 (4k) programs/cassette (2.8 Mbits.) $1500. Sykes Datatronics Inc., 375 Orchard St., Rochester, NY 14606. Phone(716)458-8000. **267**

PICTURE, PATTERN, OR PLOT



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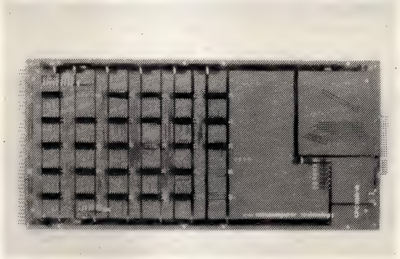
Circle No. 62

FLOPPY-DISC TESTER PERFORMS QUALITY CONTROL INSPECTION. Testette model 33FD is offered to both manufacturers and large end-users to establish the quality of floppy discs. It tests for modulation, missing pulse and extra pulse with a throughput of 1, 1.6, or 3.2 minutes. Tests are made at singular, adjustable analog clipping levels and performed over 234 tracks. Delivery is 90 days ARO. $18,500. Three Phoenix Co., 10632 N. 21st Ave., Phoenix, AZ 85029. Phone(602)944-2222. **268**



CONTROLLER INTERFACES MINI'S CPU TO QUALITY PERIPHERALS. The model CPC 100 character printer controller interfaces the Computer Automation Alpha 16, LSI-1 and LSI-2 to either the Diablo (Xerox) model 1200 Hytype or the Qume Q30 and Q45 character printers. This controller provides proportional spacing, 2-color ribbon and incremental plotting for a print speed of 45 cps. A keyboard input option is available. $450. MiniComputer Technology, 1901 Old Middlefield Way, Mt. View, CA 94043. Phone(415)965-4567. **269**

8-CHANNEL COMMUNICATIONS MUX IS READY FOR THE PDP-8/E. Combining 8 duplex asynchronous serial line interfaces—a multiplexer and a computer interface on 1 multilayer pc board—the SLIM (Serial Line Interface Module) board gives PDP-8/E computers a new communications capability. Transmit and receive frequencies are selectable from 12 crystal-controlled and 3 adjustable ones (50 to 9600 baud). The interface was designed for ease of programming systems that handle multiple serial communications lines. $1980. Computer Interface Systems, Inc., Box 58, Piscataway, NJ 08854. Phone (201)463-8279. **270**

LONDON FIRM OFFERS TI USERS LOW-COST INTERFACES. Users of TI 960 and 980 series computers now have an English source for interfaces. An interface for any Centronics printer, complete with cable and software driver, sells for $500. An adapter unit that allows the use of a *Diablo model* 4043 disc unit with a TI series 30 disc controller is priced at $375. No software modification is required. Coltec Data Systems Ltd., 17 Elm St., London WC1X OBJ. Phone(01)837-0647. **271**

REMOTE CONTROLLED CASSETTE DECK OFFERS DEPENDABILITY. Featuring design simplicity, this high sound fidelity cassette-tape transport is available for <$100. Originally designed for classroom work, the deck is ideal for dial access retrieval, telephone answering systems, dictation equipment and digital or analog signal recording. Four separate motors allow complete remote control of take-up, rewind, play or record and head engagement. Individualized Instruction, Inc., Box 25308, Oklahoma City, OK 73125. Phone(405)528-8444. **272**

4k 9-BIT nMOS MEMORIES PROVIDE A CHOICE IN SPEEDS. The MICRORAM 1200N and 1210N systems feature small board size, TTL compatibility and a variety of bit configurations. The memory systems consist of a 4096 word 9-bit semiconductor array with support electronics that provide address and data buffering, timing and control. Optional bit configurations provide the user with custom memory capabilities. Access and cycle times range between 900 and 275 nsec. Priced from $495 to $617, with delivery 60 days ARO. Electronic Memories & Magnetics Corp., 12621 Chadron Ave., Hawthorne, CA 90250. Phone (213)675-6303. **273**

8-DIGIT CALCULATOR CIRCUIT HAS INDEPENDENT MEMORY. The MK 50203N, a MOS/LSI calculator device, features 4 functions, percentage, automatic constant, reciprocal calculation, exchange (display and constant register) key, floating point operation and leading zero blanking. Single voltage operation, direct segment drive to LED displays, low power consumption and scan keyboard entry make it suited for hand-held calculator applications. $6 in a 28-pin plastic package. MOSTEK Corp., 1215 W. Crosby Rd., Carrollton, TX 75006. Phone(214)242-0444. **274**

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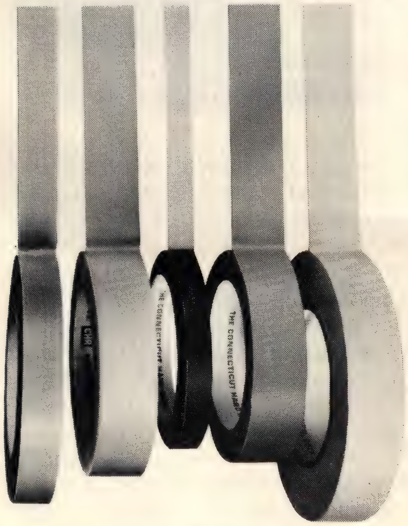
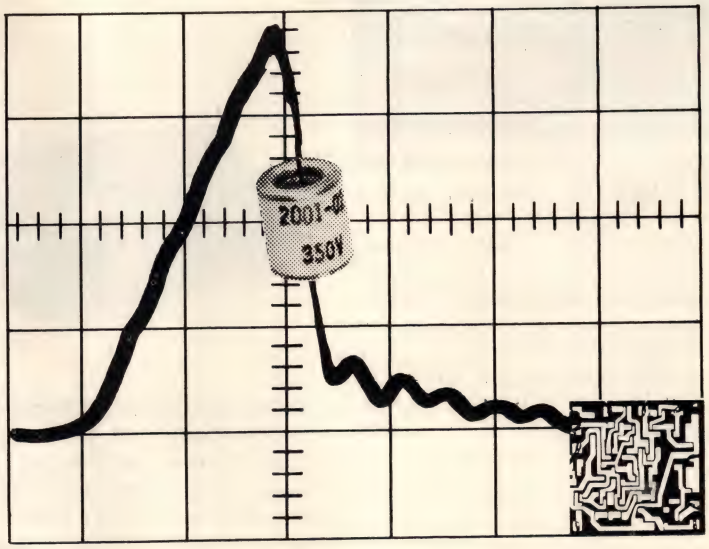


Circle No. 63

The Cocky and inexpensive Little Transient Quencher From Joslyn



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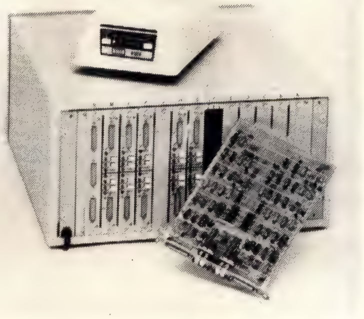
HAND-HELD DIGITAL MEMORY SCOPE IS PORTABLE. The Mitscope MS-416 is used for diagnostics in electronic calculators, digital clocks and timers, automotive electronics and other digital circuitry. It features a 4-channel capability, a normal or storage mode and a time base adjustable down to 0.5 μsec. MITS, Inc., 6328 Linn, N.E., Box 8636, Albuquerque, NM 87108. Phone(505)265-7553. **275**

HALF-PAGE ALPHANUMERIC IMPACT PRINTER CUTS COSTS. The Matri-Dot alphanumeric tape printer DMIP-2 prints 40 columns at 100 cps into a 7×5 dot matrix to form a full ASCII set of 64 characters on 6 in. roll paper. An inked platen yields 200,000 lines of print and eliminates ribbon foul-ups. DMTP-2 is available with all common interfaces including RS-232. Size is 14-1/2×8-1/2×5-1/4 in. Delivery is 4 wks. ARO. $701. Practical Automation, Inc., Trap Falls Rd., Shelton, CT 06484. Phone (203)929-1495. **276**

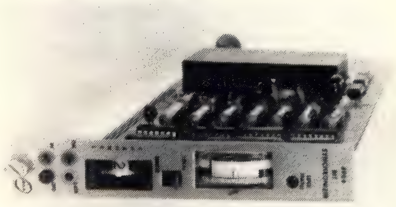
MOS-LSI REDUCES PRICE OF ALL-DIGITAL 9600 BPS MODEM. It also gives this M-96 modem superior performance on basic 3002-type lines. Designed for use in 4-wire point-to-point applications, the M-96 operates at 9600, 7200 or 4800 bps as set by the user. It includes extensive test features and offers a wide range of options that includes 2- or 4-port multiplexers and remote test (including remote loopback). Available 90 days ARO. $5000. Paradyne Corp., 8550 Ulmerton Rd., Largo, FL 33540. Phone(813)536-4771. **277**

"STOP WATCH" AUDIO/VISUAL SIGNAL INCREASES JOB THRUPUT. Using an audible tone plus a blinking light, this device automatically notifies the operator when System/3 computers are in a halt or stand-by mode. It eliminates non-productive computer time and frees the operator from the need to periodically check the computer. Only the size of a small hand calculator, it is easily installed behind the CPU front panel. $150. Business Systems Technology, 1215 W. Katella Ave., Orange, CA 92667. Phone(714)997-1450. **278**



LOW-COST DATA SET EMULATES EXPENSIVE PRIVATE LINES. Directran, an asynchronous data set, is used to serve in local or point-to-point networks up to 22 miles from a central processor. It connects computer terminals to a front-end processor and as such interfaces directly with teletypewriters, CRT's, graphic terminals, printers and data acquisition systems. Contained on a single board, it operates at rates up to 2400 bps. Prices start at $370. Computer Transmission Corp., 2352 Utah Ave., El Segundo, CA 90245. **279**

BASIC LANGUAGE ROUTINES GET EASY ACCESS TO FOURIER DATA. Option 720 adds BASIC to the model *5451B* Fourier analyzer system. Users can now synthesize and do point-by-point arithmetic on Fourier data called *from disc storage*. With keyboard entry of Fourier operations and terminal entry of Basic programs, a needed communication link is formed by the common storage use of a mass disc peripheral. Call statements link subroutines and programs into one continuous system. $1500. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501. **280**



LOW-COST BIT SYNCHRONIZER HAS 8-CHANNEL CAPACITY. The 4904 Series system handles all common codes (NRZ-L, M, S; BI-Φ-L, M, S; RZ or DM-M, S). Code conversion option outputs constant NRZ-L. Tunable from 15k bps to 4M bps, it allows reproduction and processing of serial bit streams without prior knowledge. Automatic switching of synchronizer bit rates is provided by the recorder tape speed control. $9000, $12,000 with conversion. Data-Control Systems, Inc., Commerce Dr., Danbury, CT 06810. Phone(203)743-9241. **281**

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TEMPERATURE
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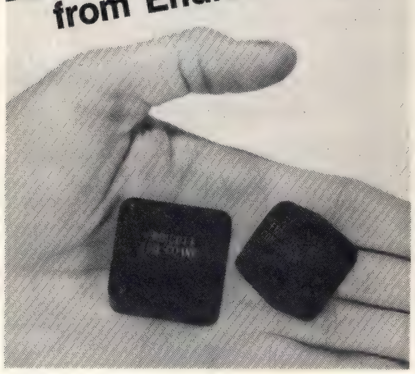

Standard E-700 Series units convert low DC line voltages of 5, 9, 12 or 15 volts DC to nominal 200 volt DC level @ 15 MA to activate any multi-segment gas-discharge-type numerical readout. Available both in unregulated and regulated units.

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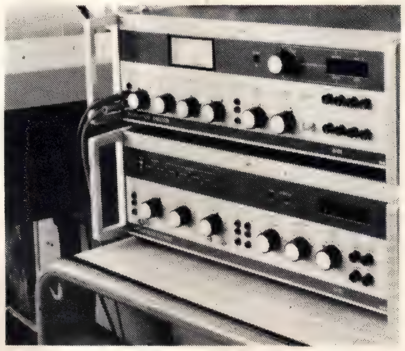
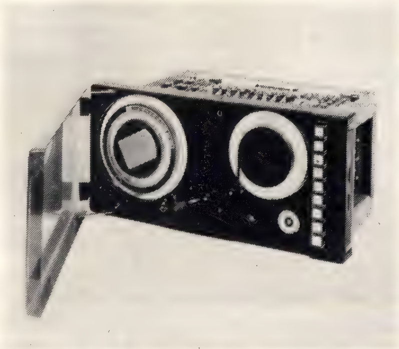
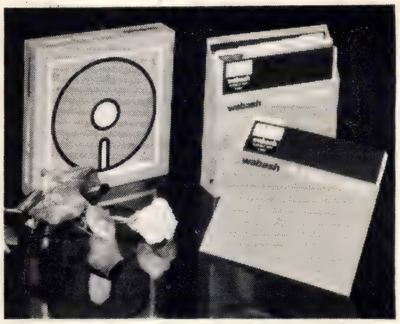


INSTRUMENT PAIR RECORDS ALL DATA-LINE DISTURBANCES. With the impulse noise counter 4 H82 and the interruption analyzer 4 H81, data-line noise pulses and interruptions can now be evaluated with great accuracy. Featuring several threshold levels, counter/registers, automatic recording and a digital readout, these units are useful for fundamental network studies as well as for maintenance. Siemens Corp., 186 Wood Ave., South Iselin, NJ 08830. Phone(201)494-1000. **282**

MICROPROCESSOR SOFTWARE IS AVAILABLE AT LOW COST. A complete line of support software has been developed for the Intel family of μP's (8080, 8008, 4004). This software is implemented in FORTRAN IV for most computers. The assemblers provide symbolic addressing and constant generation. The simulators provide commands to set breakpoints; to display and patch memory locations; and to display, modify and simulate registers and I/O's. Assemblers—$500; simulators—$650. Microtec, Box 337, Sunnyvale, CA 94088. **283**



TAPE TRANSPORTS USE 50% LESS POWER. Models 85X and 70X operate at selected speeds up to 37.5 ips using 8-1/2- or 7-in. reels. They are available in 7 track (with a choice of 2 densities from 200, 556 or 800 bpi) or in 9 track (in either 800 bpi NRZI or 1600 bpi IBM phase encoded formats). Crystal-controlled speed, acceleration, write and read deskew, and switch-controlled speeds are the electronic features which provide high performance. $2700 and $2450, respectively. Cipher Data Products, 7655 Convoy Ct., San Diego, CA 92111. Phone(714)277-8070. **284**



77-TRACK FLEXIBLE DISC IS CERTIFIED 100% ERROR-FREE. The Quadronix flexible disc recording characteristics include 77 tracks, IBM (and similar disc drive) compatibility and a density of 3200 bpi. It also features a capacity of 242, 944 bytes (128 character records), 26 sectors of 128 characters/track and an expected life of 3500 hrs. or 1 million revolutions/track. Wabash Tape Corp., Dept. GC-D, 2720 Des Plaines Ave., Des Plaines, IL 60018. Phone(312)298-8585. **285**

μP HANDLES FLOPPY-DISC DATA FOR THIS CRT DISPLAY. This system serves as a data entry, super-intelligent terminal or as a stand-alone computer. With IBM 3740 compatible floppy-disc drives and a 1280 character display, it also features 512 I/O ports, a memory expandable to 64k bytes and an assembler. Using Intel's 8080 instruction set, the processor easily develops and tests microprocessor programs. The Isys Corp., 5404 Harvest Moon Lane, Columbia, MD 21044. Phone(301)497-0379. **286**

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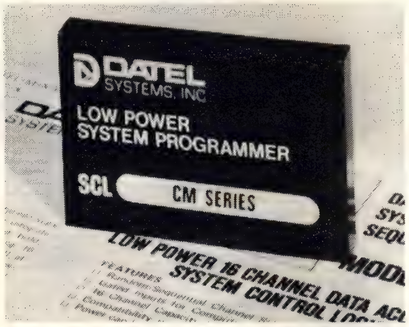
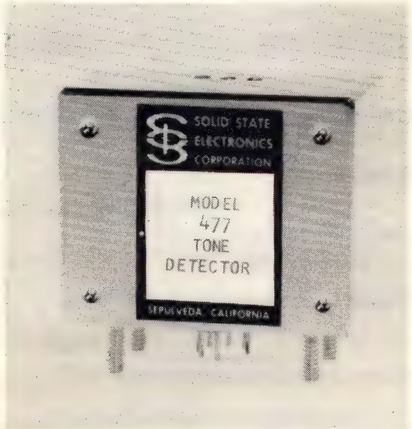


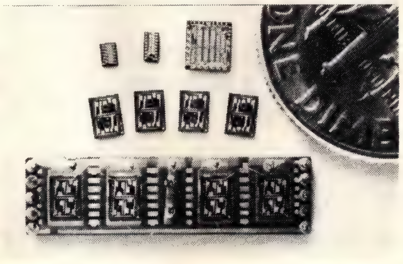
LOW-POWER SEQUENCER/CONTROLLER SIMPLIFIES DATA ACQUISITION. Model SCL-CM will control up to 16 analog data channels. It reduces the external control functions to a simple ready/busy strobe technique, providing either random or sequential channel selection modes. It has provision for short cycle (<16 channel) and provides a frame sync at channel 1 for system expansion. Standby power drain is 120 µW. $79, with delivery 4 wks. ARO. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone(617)828-8000. **170**

THIN-FILM ATTENUATOR RESISTORS CONFIGURED AS BINARY STRING. The AD1807-series networks are designed for binary attenuation from R/2 to R/1024. With "R" values from 10k to 1 MΩ, the networks feature TCR tracking to 1 ppm/°C, noise to −50 dB, long term ratio stability to ±0.005%/yr, ratio matching accuracies to 0.01% and resolutions to 0.001R. 100-pc price as low as $6. Analog Devices, Inc., Rte. 1 Industrial Park, Norwood, MA 02062. Phone(617)329-4700. **171**



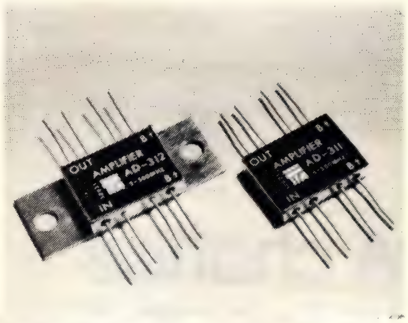
TONE DETECTORS COVER WIDE FREQUENCY RANGE. Series 477 detectors are available over the range of 300 Hz to 100 kHz. They will accept sine, square or triangular input signals. Frequency and bandwidth settings are virtually insensitive to environmental conditions or supply variations. Solid-state switch output minimizes RF noise and improves response time. $99 (100). Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. Phone(213)894-2271. **172**

SAMPLE-HOLD CIRCUITS PACKAGED IN 16-PIN DIPS. The IH5110 and IH5111 are offered in MIL and commercial versions. Drift rate (all devices) is 10 mV/sec max. and <2 mV/sec typ. Max. acquisition time for a 10V step input is 10 µsec for the IH5110, 15 µsec for the IH5111. Both units have 500-nsec aperture time. Prices in 100 quantity for industrial versions are $21.50 (IH5110) and $22.50 (IH5111). MIL versions are $29.50 and $29.90, respectively. Intersil, Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. Phone(408)257-5450. **173**



DIGITAL WATCH KIT OFFERS MULTIPLE LED DISPLAY OPTIONS. The LWS-6120 kits are all based on the LMC-6120 CMOS timekeeping chip which counts hours, minutes and seconds. Also included are the LBC-1060 digit driver and the LBC-1070 segment driver. All 3 circuits are provided in chip form for hybrid assembly methods. Eight display options are available. $32 (100). Litronix, Inc., 19000 Homestead Rd., Cupertino, CA 95014. Phone(408)257-7910. **174**

COATED SUBSTRATES FEATURE NICHROME RESISTIVE ELEMENTS. The AD1900 series 2-film system consists of a nichrome resistive coating covered by a 150-µin gold conductive layer. Surface finishes of 3-4 or 5-10 µin. are available. The substrates may be specified with resistivities from 50 to 500Ω/square, noise to −50 dB, power to 50W/in.^{2} and long term stability to 0.005%/yr at 25°C. Analog Devices, Inc., Rte. 1 Industrial Park, Norwood, MA 02062. Phone(617)329-4700. **175**



HERMETICALLY-SEALED AMPLIFIERS IMPROVE RELIABILITY. The AD-300 series covers the frequency range from 5-500 MHz. The 10-dB gain feedback amplifiers are available in 3/8×1/2×1/8-in. case sizes. They have 1-dB output compression points of +16 dBm and max. NF of 3 dB (AD310). Input and output VSWR's are 1.8:1 and 2:1, respectively. $79 to $88. Technical Research and Mfg. Inc., Grenier Field, RFD 3, Manchester, NH 03103. Phone(603)668-0120. **176**

RESISTOR NETWORKS DESIGNED AS CUSTOM HYBRID SUBSTRATES. The substrates contain bonding pads for chip capacitors, IC dice and passive resistors. Metal-film interconnections provide high reliability. Film resistance values from 1k to 10 MΩ are standard, with tolerances as low as 0.01% at 25°C. TCR is typically ±25 ppm/°C, with tracking of ±5 ppm/°C. Power rating/resistor is 50 mW. Allen-Bradley Co., 1201 S. Second St., Milwaukee, WI 53204. Phone(414)671-2000. **177**

MULTIFUNCTION MODULES PERFORM OVER WIDE DYNAMIC RANGE. MF433-series function modules perform the operation $Y(Z/X)^M$, with M variable from 1/5 to 5. Over a 1000:1 dynamic range of input, output errors are 10 mV max. (MF435) in multiplication mode, and 50 mV typ. in division mode. Value of M is selected by external resistors, with no external gain or offset adjustments required. $75 to $145. Delivery 6 to 8 wks. ARO. Intronics, Inc., 57 Chapel St., Newton, MA 02158. Phone(617)332-7350. **178**

TECHNITROL Takes The Tough PT'S.

When it comes to pulse transformers (PT'S), Technitrol's experience leads the field. Technitrol was first with DIP transformer packaging and the H case. But, Technitrol is first where it really counts: getting the job—no matter how tough—done right. Here are two examples:

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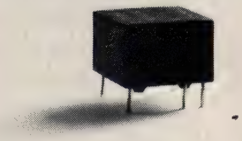

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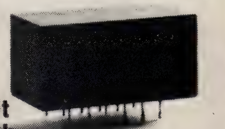

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T-1

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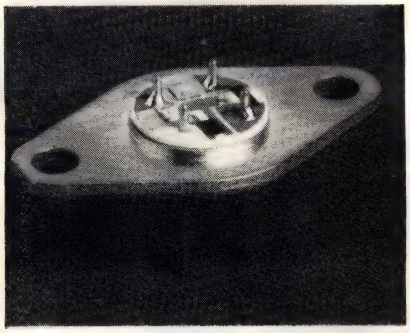
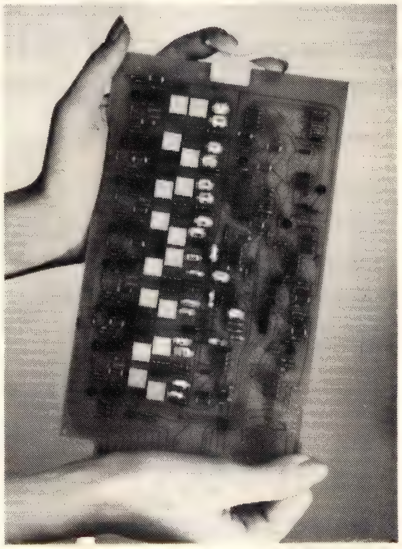


POWER SWITCHES BOOST SWITCHING-REGULATOR EFFICIENCY. The PIC600 series of hybrid devices provide the power transistor and catch diode in a single TO-66 package. The devices operate at more than 80% efficiency. Careful matching of switching speeds of the 2 active devices minimizes turn-on overshoot. The series includes positive and negative versions for 5 and 15A applications, with either 60 or 80V max. input voltage. Unitrode Corp., 580 Pleasant St., Watertown, MA 02172. Phone(617)926-0404. **179**

TRANSMIT/RECEIVE RELAY PROVIDES HIGH POWER CAPABILITY. The SLS-4TR has a freq. range to 32 MHz, with power capability of 10 kW average (100 kW pk) and a 2:1 load VSWR. In the transmit mode, the relay grounds the receiver port for max. receiver protection. An interlock system removes RF power from the relay before the RF circuit is open, and delays application of RF power until the path is established. Delta Electronics, Inc., 5534 Port Royal Rd., Springfield, VA 22151. Phone(703)321-9845. **180**

ADC RESOLVES TO ONE PART IN 20,000 WITH 0.01% ACCURACY. The ADC1105 converter uses external counters and registers to allow resolution to 14 binary bits or 4 BCD digits. Specs include 2 μV/°C zero stability and 5 ppm/°C gain TC. It accepts both bipolar and unipolar inputs of ±10 and ±1V F.S. range. The ADC1105J, accurate to 0.1% is $115(100); the ADC1105K, with 0.01% accuracy is $150(100). Analog Devices, Inc., Rte. 1 Industrial Pk., Norwood, MA 02062. Phone(617)329-4700. **181**

CRYSTAL-CONTROLLED OSCILLATOR REQUIRES NO OVEN. Model CXO-115 can be ordered for any frequency between 1 and 15 MHz. Rise and fall times are 75 nsec max. Frequency tolerance is ±0.005%, with stability of ±10 ppm/°C. Operating from 5V supply, the output is compatible with most TTL and DTL families. Standard temp. range is −25 to +75°C. $49 (100). Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. Phone(213)894-2271. **182**



TOUCH-TONE^{R} RECEIVER OFFERS RELIABILITY AT LOW COST. The CM7208 comes complete on a single circuit card, and draws only 20 mA. The receiver can be used in central offices, PBX's or end-to-end signalling. It has ac-coupled balanced inputs of 50 kΩ, and operates from a 12 or 15V supply. Outputs of the CM7208 are directly compatible with TTL/CMOS logic. $140(1000). Mitel Corp., Box 704, Ogdensburg, NY 13669. Phone(613)836-2118. **183**

GAS-DISCHARGE DISPLAY VOLTAGES PRODUCED FROM LOGIC SUPPLIES. These hybrid IC converters, powered by standard logic supplies, produce output voltages from +180 to +270V dc. Model PS1510D operates from +5V dc and produces +200V dc at 1 mA. The PS1515D converts +5V into +180V dc at 15 mA. PS1520D outputs 200 to 270V dc from input of 12 to 16V. Military and commercial versions are available. LRC, Inc., 1001 Digital Dr., Hudson, NH 03051. Phone(603)883-9351. **184**

IF AMPLIFIERS DESIGNED FOR TELECOMMUNICATION SYSTEMS. IFA-series amplifiers are designed for use in up-down converters. Center frequencies of 70, 700 and 1100 MHz are available. Features include 0.5-nsec group delay, 0.1-dB bandpass flatness, 30-dB reverse isolation and return losses of 23 dB. NF ranges from 3.5 to 8 dB, with power outputs at 1-dB compression from +3 to +21 dBm. Microwave Power Devices, Inc., Adams Ct., Plainview, NY 11803. Phone(516)433-1400. **185**

AC/DC CONVERTER PACKS BIG POWER INTO SMALL PACKAGE. The Series 300 module measures 2×3×1-in., weighs 13-1/2-oz. and operates over the entire military temp. range. The converter accepts 3-phase, 400 Hz input and develops single or dual unregulated outputs. Typical output ranges include 20V at 5A, 40V at 2.5A and dual 20V at 2.5A ea. $100. Delivery is 4 wks. ARO. Powercube Corp., 214 Calvary St., Waltham, MA 02154, Phone(617)891-1830. **186**

S-BAND FREQUENCY SYNTHESIZER PROVIDES HIGH STABILITY. Model 6550 operates in the 2830-2990 MHz frequency range. It provides 10-MHz steps in 10 msec/step across the band with a min. of 100 mW power output. The frequency stability is better than 1 part/million over 0 to 50°C. A 5- or 10-MHz external reference can also be used. Zeta Laboratories, Inc., 616 National Ave., Mt. View, CA 94043. Phone(415)961-9050. **187**

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LITERATURE

IC'S. A 6-pg., 2-color brochure lists applications, performance features and maximum ratings of CMOS 4000 Series digital IC's. These are intended for 3 to 15V applications. It contains schematic logic diagrams, typical characteristics, package dimensions and detailed ordering information. Stewart-Warner Microcircuits, 730 E. Evelyn Ave., Sunnyvale, CA 94086. **243**

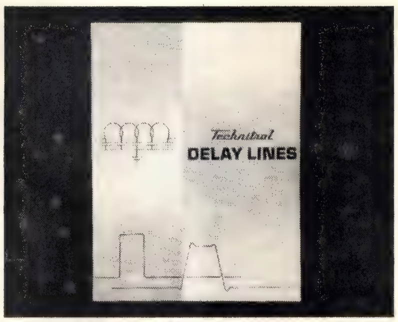
POWER SUPPLIES. This 130-pg. catalog contains simplified schematic and mechanical drawings of more than 30 power supply designs, encompassing many hundreds of separate models. In its Handbook section, there are discussions of ferroresonance, thermal design criteria, measurement techniques, programming, digital control, high-speed dynamics, operational theory and multi-unit interconnections. An up-to-date power supply glossary is also included. Kepco, Inc., 131-38 Sanford Ave., Flushing, NY 11352. **244**

IC DESIGN. MONOGRAM #5 contains a feature article on the design of op-amps with the Monochip. It describes a number of practical circuits. In addition, this 12-pg. quarterly illustrates 3 new products that employ passive components, transistors and the company's Monochip. Interdesign, Inc., 1255 Reamwood Ave., Sunnyvale, CA 94086. **245**

LINEAR AND INTERFACE CIRCUITS. This 370-pg. application book stresses practical applications. There is detailed coverage on operational amplifiers, comparators, video amplifiers and special functions. Also included are chapters devoted to peripheral drivers, MOS interface circuits, core memory and line transmission circuits. $6.95. Texas Instruments, Inc., Box 3640, M/S 54, Dallas, TX 75221. **INQUIRE DIRECT.**

PHOTOTRANSISTORS/DARLINGTONS. The 8-pg. brochure describes the 2 basic chip sizes for either phototransistors or photodarlingtons along with various packaging configurations such as TO-18, pill, coaxial and ceramic header. In addition to mechanical data, Bulletin VTTA-I also includes electro-optical parameters, 24 graphs of characteristics and environmental information. Vactec, Inc., 2423 Northline Industrial Blvd., Maryland Heights, MO 63043. **246**

TWO KEYBOARDS. Product sheets on the first 2 low-profile units in the SD line of electronic keyboards are offered. Sheet 51SD12-1 describes a typewriter-style keyboard suited to word processing and phototypesetting applications. Sheet 26SD1-1 provides data on a point-of-sale keyboard designed for compact terminals. Micro Switch, 11 W. Spring St., Freeport, IL 61032. **247**



DELAY LINE CATALOG includes definitions and measurements of parameters, typical test set up, applications, cost factors, case styles and lead layout. Technitrol, Inc., 1952 E. Allegheny Ave., Philadelphia, PA 19134. **248**

NONLINEAR CIRCUITS HANDBOOK. Its 540 pages provide a complete reference to the principles, circuitry, specs, testing and applications of nonlinear analog building blocks. Heavily applications oriented, it treats areas such as function-fitting, time-function generation, instruments and data acquisition, signal processing, computing and control. $5.95. Analog Devices, Inc., Rte. 1 Industrial Park, Norwood, MA 02062. **INQUIRE DIRECT.**

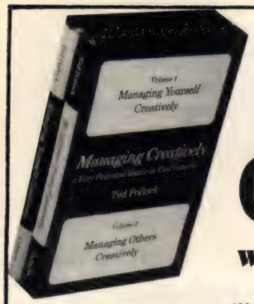
THYRISTORS AND RECTIFIERS. A tabulation of thyristors (SCR's, ITR's and triacs), diacs and rectifiers appears in this 68-pg. pocket-size directory. These devices are classified according to voltage and current rating, gate characteristics and package styles. RCA Solid State Div., Box 3200, Somerville, NJ 08876. **250**

CASSETTE MINIDRIVE. A digital cassette minidrive that emulates 1/2-in. tape transports at the interface connector is described in a 4-pg. brochure. Recording methods, storage capacity, track formats, physical characteristics, advantages and compatability are listed. Request bulletin PCD-40102. Datum, Inc., 1363 S. State College Blvd., Anaheim, CA 92806. **251**

INSTRUMENTS CATALOG. This 32-pg. catalog provides complete information on digital printers, frequency counters, counter-timers, communications counters, calculating counters, voltage to frequency converters and frequency to dc converters. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, CA 91406. **252**

CMOS PROGRAMMED TEXT. Structured as a self-teaching aid to familiarize design engineers with CMOS, the 80-pg. CPI-279 covers CMOS fundamentals, packaging and circuits. The reader learns through a series of progressive steps or "frames." A glossary is included. $2. RCA Solid State Div., Box 3200, Somerville, NJ 08876. **INQUIRE DIRECT.**

µP LOGIC NOTEBOOK. This monthly newsletter discusses how to select, apply and program microprocessors and microcomputers. A full-color wall chart displaying the features of every known µP comes with the free first issue. Annual cost is $95. Microcomputer Technique, Inc., 11227 Handlebar Rd., Reston, VA 22091. **253**



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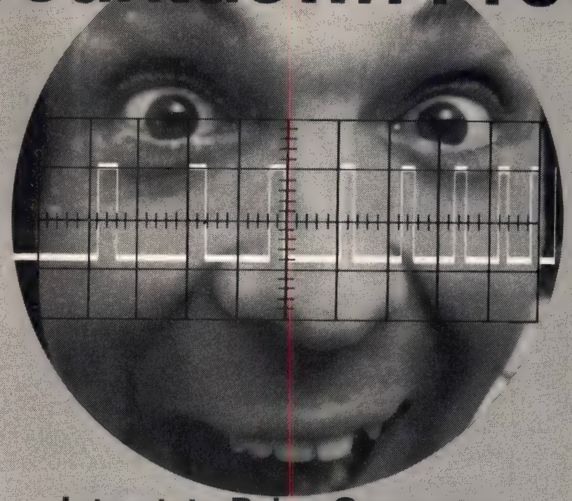

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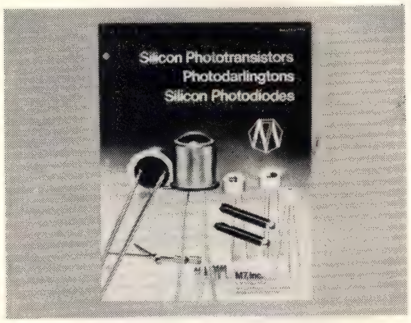
LITERATURE



Silicon Phototransistors
Photodarlingtons
Silicon Photodiodes

SILICON PHOTODEVICES. Bulletin PT-74 includes electrical and mechanical specs on general-purpose and "high-density" phototransistors, high-sensitivity photodarlingtons and photodiodes. M 7, Inc., 210 Campus Dr., Arlington Heights, IL 60004. **254**

WORLD'S FASTEST MINI. A 12-pg. product bulletin on the high-speed, 16-bit Model 85 minicomputer covers its features, specifications and instruction repertoire. I/O modes, software support and the memory system are also detailed. Interdata, Inc., 2 Crescent Pl., Oceanport, NJ 07757. **255**

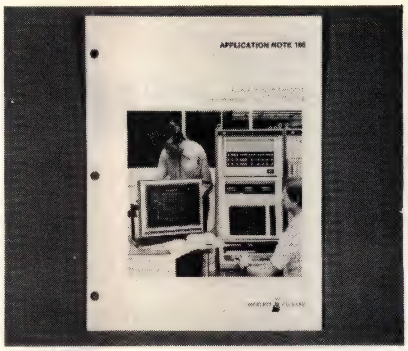
MASS-MEMORY SYSTEMS FOR MINI'S. This 2-color condensed catalog contains descriptions and specs for mass-memory magnetic storage systems for minicomputers. Covered are 12 magnetic disc drives, a cartridge disc drive, a new floppy disc drive and 2 magnetic tape systems. Controllers are included. Most systems discussed have standard interfaces for DEC, Interdata, Nova and DCC minicomputers. DIVA Inc., 607 Industrial Way W., Eatontown, NJ 07724. **256**

HEAT-SHRINKABLE PRODUCTS. A "mini" catalog describes and illustrates shrinkable tubing, end caps and electrical tape. Sizes, colors and shrinkage ratio charts are included where applicable. This scaled-down booklet was designed for the expedience of engineers and buyers. Cole-Flex Corp., 91 Cabot St., West Babylon, NY 11704. **257**

SENSOR SWITCHES. Temperature sensors, proximity and ferrous sensors are detailed for the designing engineer in catalog A-90000. It illustrates and explains, with diagrams and drawings, the functions of the switch line. Switching modes are discussed, providing complete application data. Hamlin, Inc., Lake and Grove St., Lake Mills, WI 53551. **258**

IC EQUIPMENT. This 68-pg. total product catalog, IC-1075, is a complete single-source package on the latest developments in IC connection methods and equipment. It features details and test data on IC sockets, complete socketboard systems and IC interconnect accessories. Robinson-Nugent, Inc., 800 E. Eighth St., Box 470, New Albany, IN 47150. **259**

SERIAL DIGITAL TIME CODES, the most commonly used ones, are described in this monograph. It lists many time-code applications for both industrial and scientific programs. Chrono-Log Corp., 2583 W. Chester Pike, Broomall, PA 19008. **260**



APPLICATION NOTE 166

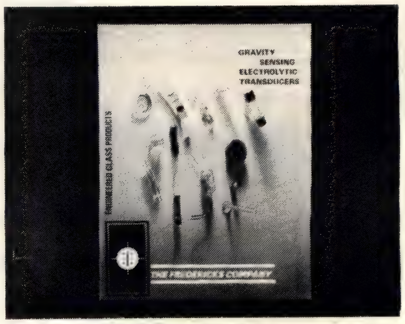
CRT DISPLAYS. Exact information on how to apply large-screen CRT displays is contained in Application Note 166. To help obtain maximum display usefulness, the app note gives input requirements, attenuator calculations, data on Z-axis modulation and details on options to satisfy special requirements. Hewlett-Packard Co.,1501 Page Mill Rd., Palo Alto, CA 94304. **261**

INDUSTRIAL SLIDES. An illustrated 28-pg. handbook explains the many factors related to the selection and use of industrial slides. This booklet illustrates how, through the use of slides, it is possible to create more efficient and valuable products. Case histories on slide applications are included, as are specific slide descriptions, installation details and related materials. Grant Hardware Co., High St., West Nyack, NY 10994. **262**

ANTENNAS. This 70-pg. brochure discusses broadband antennas and various antenna designs. Topics covered are horn, spiral, log periodic, omnidirectional and rotating direction-finding antennas. GTE Sylvania, Antenna Capabilities, Box 205, Mt. View, CA 94042. **263**

21MX COMPUTER SERIES. A 76-pg. brochure-manual describes this family of minicomputers. It discusses the microprogrammable control processor, the RAM memory system, the writable control store option and other operating features. It also includes extensive programming instructions. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. **264**

METROLOGY CATALOG. Eighty pages cover precision measurement instruments for voltage, resistance and capacitance. Also included are digital and linear testers, generators and detectors, standards, decades, dividers and high-precision resistors. Production laser systems for resistor trimming and substrate scribing are touched on briefly. Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, OR 97229. **265**



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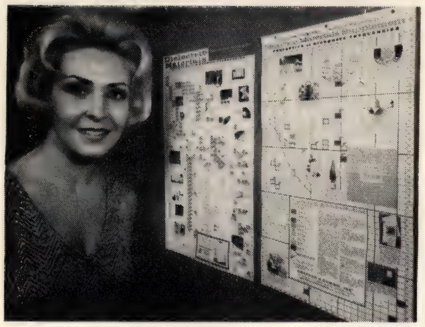
ELECTROLYTIC TRANSDUCERS. A 4-pg., 2-color bulletin covers operating principles, applications and complete specifying data for gravity sensing electrolytic transducers. Diagrams show output sensitivity and response characteristics. The Fredericks Co., Huntingdon Valley, PA 19006. **266**

CHARTS SHOW PROPERTIES OF DIELECTRIC MATERIALS



Two charts in full color show dielectric and other properties of hundreds of materials used by electrical/electronic engineers . . . arranged by dielectric constant and dissipation factor. Send for free copies.

Circle No. 4

NEW TECHNICAL DATA ON EPOXY CASTING RESINS

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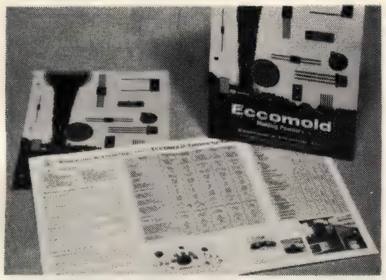

Comparative physical, electrical and processing properties of Eccomold transfer molding compounds are in colorful chart. Typical applications are indicated.

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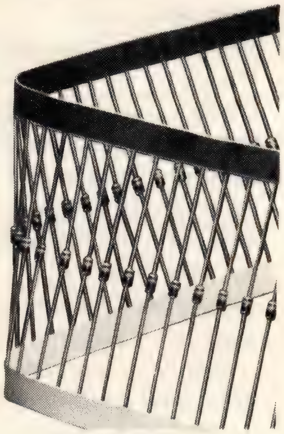

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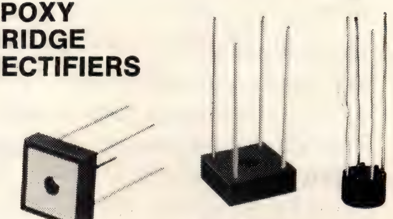

- 1A, 2A, 6A and 10A (I_O)
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Circle No. 72

signals and noise

A Polish metronome

Dear Sir:

We were interested by Tim Henry's interval timer (EDN Design Awards, 3/20/74 issue), but were having a little difficulty finding an application for it—until one of the group suggested what should have been obvious in the first place from the tone-generator and speaker output: It's a Polish metronome!

Henry's selection of a programmed unijunction instead of a McMOS package for the bistable element was a little surprising for a Motorola-type designer. Was this a subtle hint that the whole thing is a PUT-on?

Henry may have been kidding, but he's got the germ of an idea there with tremendous commercial possibilities. Envision, if you will, 52 of these devices with selected tone-generator components spanning four octaves: The World's Greatest All-Polish Pizzicato Orchestra! (For the World's Greatest All-Polish Cicada Orchestra, reverse the 1N914's.)

As a practical device, an "ensemble" of a handful of generators should share a single speaker, with each "musician" consisting of three 10-state devices with independent timing, a VCO tone generator (can be done with CMOS gates), and optional glissando (ramp) and tone-processing networks. The timers select tone-start, tone-stop and note (each musician has only 10 notes unless additional flip-flops are added). The tone-processing networks, to keep parts costs reasonable, are 2-Pole filters, of course.

Parts selection, layout and logic design for these ensembles are a designer's delight. Parts with truly awful voltage and temperature coefficients, unregulated voltage sources, crosstalk and logic conflicts all add to the wonderfully randomized output. The drawback right now is that parts cost alone for a small ensemble to play through your home hi-fi runs something over $50, mostly eaten up by those decoded counters. If CMOS prices would come down a bit—say, to twice TTL—the "Polish Symphony" could be turned into a first-class fad, and do the industry a great favor by becoming a sink for all the intermittent, out-of-spec and noisy parts that otherwise would become sanitary landfill.

If it catches on, Moog will be long-forgotten; "Tim Henry" will be the name on everyone's lips. We could run him for President! Of Poland.

Yours truly,
Geoffrey A. Gass
Custom Modifications Engineer
Tektronix, Inc.
Beaverton, OR 97005

He's quite right—We stand corrected!

Dear Sir:

In your July 20 issue, your West Coast Editor reports on this year's SID Symposium. Prominent among your figures is our thin-film transistor-addressed liquid crystal display (Fig. 4). You describe this as a "large area display," which it is, by far the largest and highest resolution display ever constructed with liquid crystals. It also contains the world's largest integrated circuit: 6 × 6 in., with 14,000 transistors.

Quite a significant achievement, one might think; however, we look in vain for any attribution to Westinghouse where this work was done. In the text (p. 18) you describe the same display as being "on the small side." The item being placed immediately after a description of some GE liquid crystal work, the reader is left to conclude (in the absence of any other information) that this display was also built by GE.

Yours very truly,
T. P. Brody, Manager
Thin Film Devices
Solid State Research
Westinghouse Electric Corp.
Pittsburgh, PA 15235

Bargain prices

Obviously our readers know a bargain when they see one—which is by way of introducing a recent error that slipped in on page 114 of the Aug. 20 issue (R.S. # 241). Somehow the "1" in $21.30 got dropped, causing an erroneous $2.30 to appear as the cost of new liquid crystal readouts from Industrial Electronic Engineers, Inc. The product has been rerun in this issue's "Components and Materials" product section with correct specs and price.—*Ed.*

"STOP WORRYING, BOSS, WE'LL HAVE AN INSTANT RE-PLAY IN THREE HOURS!"

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1. The 75451 series of dual peripheral drivers has a breakdown voltage of:

- ☐ 7-1/8 inches
- ☐ 30 volts
- ☐ 18 pounds

2. The National Semiconductor DS 3611 series of dual peripheral drivers, which is pin-for-pin compatible with the 75451 series, has a breakdown voltage of:

- ☐ 7-1/8 inches
- ☐ up to 80 volts
- ☐ up to no good

3. The DS 3611 is better for:

- ☐ cleaning your teeth
- ☐ driving lamps, relays and solenoids
- ☐ making pepperoni pizzas

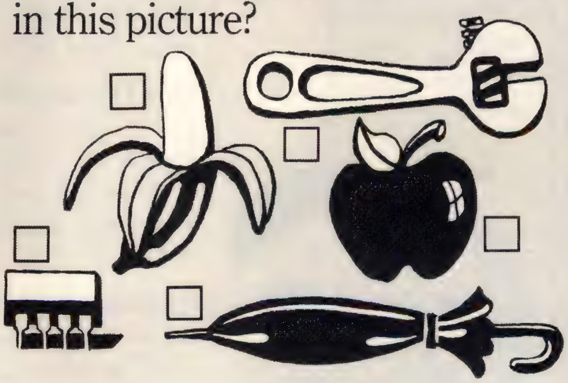
4. To use the 75451 is therefore:

- ☐ smart
- ☐ silly
- ☐ silly if you operate near or over 30 volts
- ☐ delicious if baked in a 300° oven for 45 minutes

5. To get the DS 3611:

- ☐ rub your stomach in a counterclockwise rotation as you pat your head
- ☐ hold your breath
- ☐ call your local National Distributor

6. Can you spot the DS 3611 in this picture?



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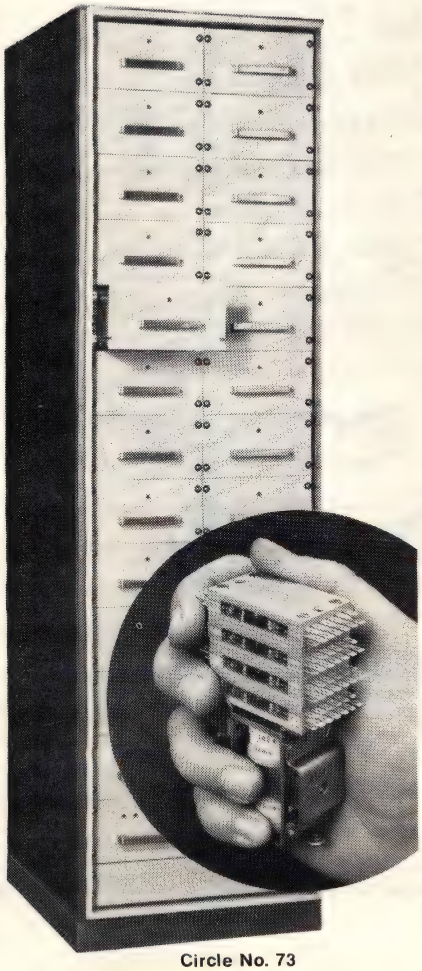

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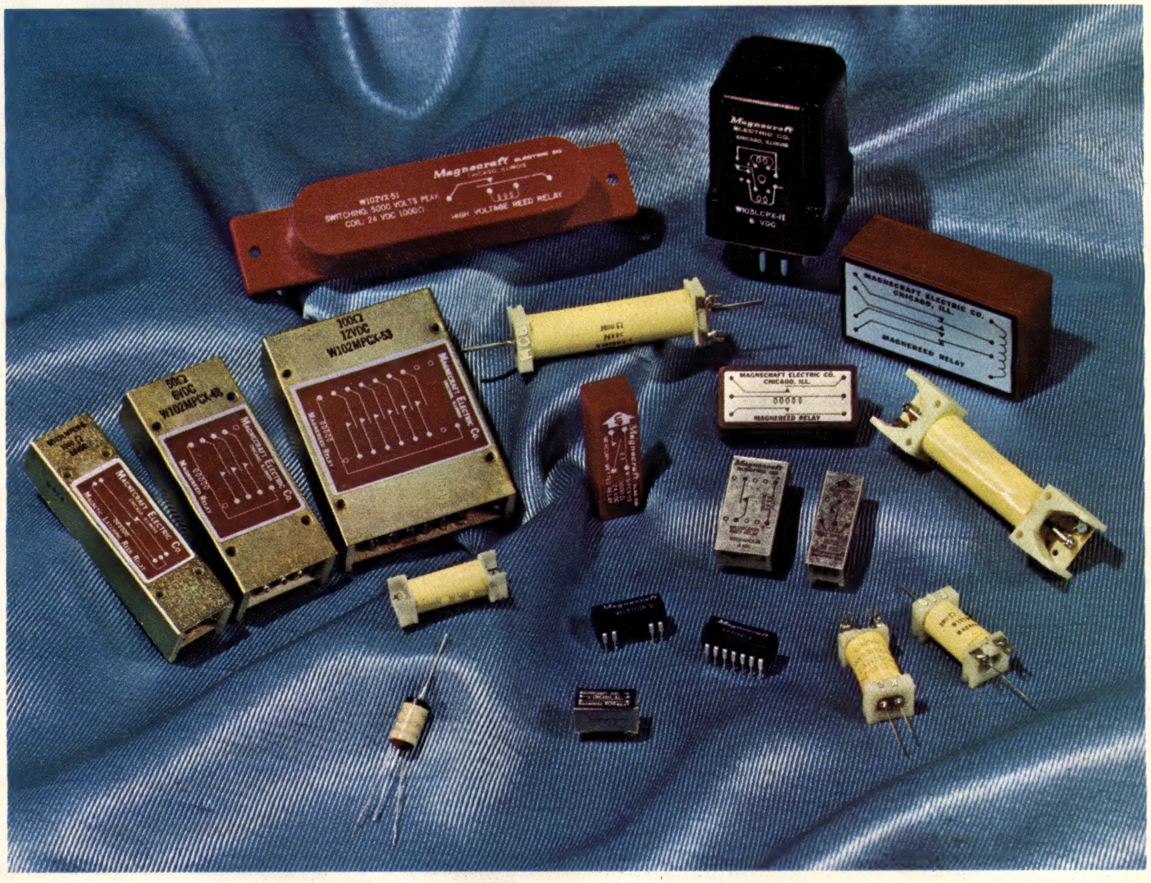
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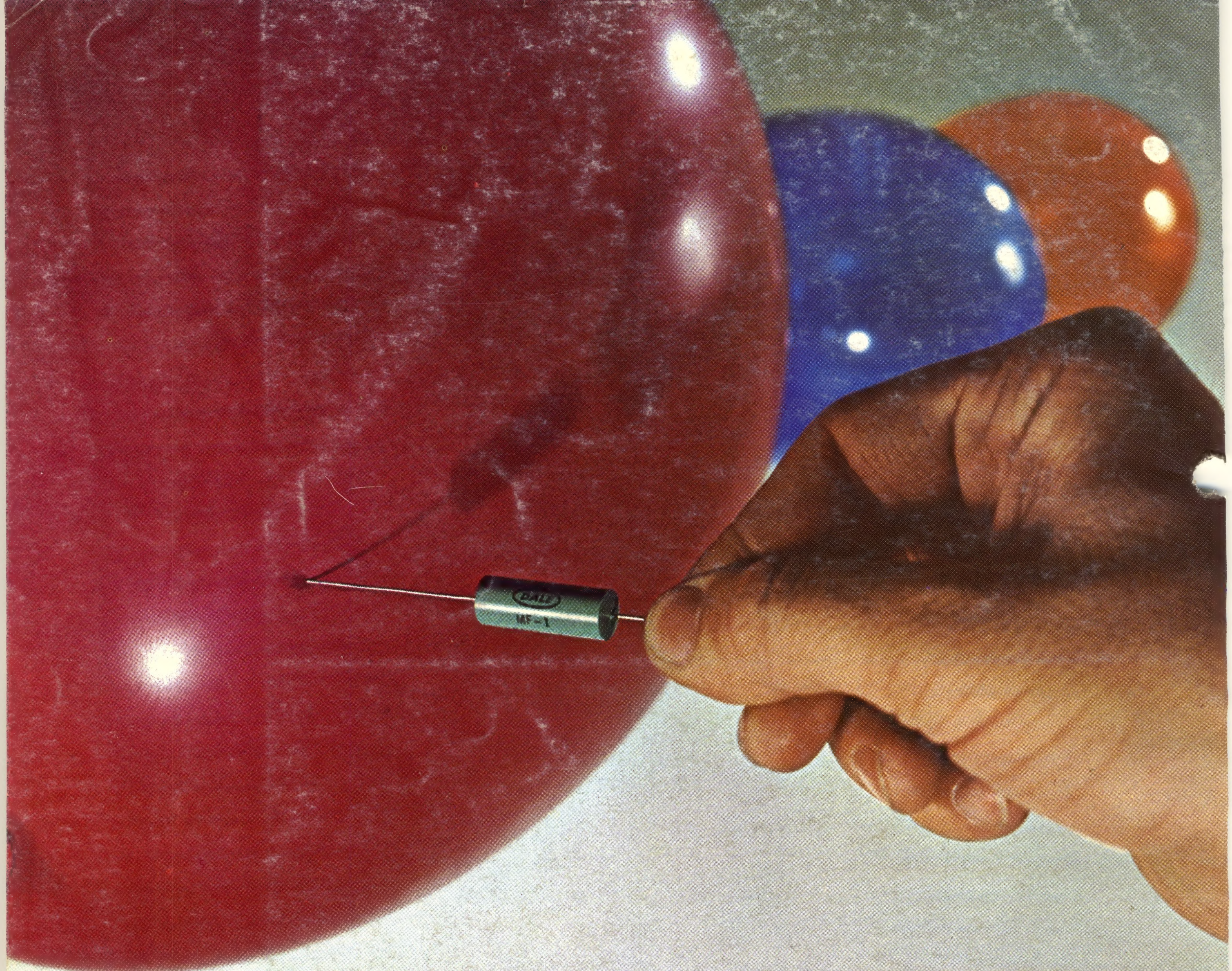

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